THE INFLUENCE OF INDUSTRIAL TECHNOLOGY AND MATERIAL PROCUREMENT ON THE DESIGN, CONSTRUCTION AND DEVELOPMENT OF H.M.S. VICTORY

Peter Goodwin

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Contents.

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Peter Goodwin. 1998.

Synopsis.

The aim of this paper is to show how industrial technology and material procurement influenced the development of British warship design and construction for the period 1760 to 1830 using the construction of HMS *Victory* as and archaeological base to work from. While much has been written about ship construction, technology and materials, these subjects have to some degree remained divorced from each other and thus need to be analysed collectively. To achieve this, this dissertation has been formulated into two parts;

Part I covers the initial orders to build the *Victory*, the concepts of ship design, construction technique, and the materials employed when she was initially built. It also covers the designer and his contribution to ship development at the period and the possibility that he was influenced by current French shipbuilding practices. In brief, this section highlights the implications and possible inadequacies of general ship design in c.1760.

Part II discusses the actual technological and constructional development of the *Victory* throughout her active career. The issues raised through this examination show that she very much reflects general ship development at the time. Besides endorsing the significant influence of industrial expansion, this section also emphasises the point that much can be learnt by analysing the ship using the same techniques as employed on an archaeological site. Sadly, the latter point has long been neglected, therefore, one of the objectives of this paper is to demonstrate that by archaeological investigation of individual timbers, a new dimension can be added to our understanding of structural development and building practices. To achieve this, I have chosen to examine HMS *Victory* as the most suitable three dimensional source, as her active working life falls within the dates specified above.

Introduction.

Some 232 years after her initial launch the *Victory* is now preserved at Portsmouth where she serves as both Flagship for the Second Sea Lord/Commander-in-Chief Naval Home Command, and as a public heritage attraction. Still retaining her formal official naval prefix of H.M.S., to the public she is affectionately known either as *The Victory* or *Nelson's Victory* due to her obvious connection with the 'immortal hero' Admiral Lord Nelson, the victor of the Battle of Trafalgar, the two are now synonymous.

Being one of few surviving historic warships much work has been published regarding history and subsequent restoration which commenced in 1922. Her restoration, initially driven by the visionary efforts of the Society for Nautical Research, ensured the survival of this renowned Trafalgar veteran. Ironically the only other Trafalgar vessel to survive into the 20th century was the French 74 gun ship *Duguay-Trouin*. Having escaped from the battle she was captured two weeks later by Admiral Strachan. Renamed as the *Implacable,* she remained in service until 1855. After this date she was used as a boys training ship until the Second World War. Found to be in very poor condition, and without funding, she was finally scuttled off the Owers on 2 December 1949. As for the other British ships that fought at Trafalgar, most had been disposed of by 1830. The *Temeraire*, immortally captured in Turner's painting, went to the breakers in 1838, and the last, the frigate *Naiad,* was sold off in 1866 to become part of a coal depot at Callao, Peru. [1]

Throughout her 'active' service the *Victory,* like any other Naval warships past or present, underwent many refits, repairs and modifications, the latter very much governed by progress in ship technology and construction technique. In all, her general appearance had varied considerably from 'as built' in 1765 to her last 'great repair' 1814 -16. Though restored to her current Trafalgar configuration, i.e. 1800-03 rebuild, the ship is in fact a compromise between this and her rebuild of 1814-16 and earlier alterations carried out in 1810. Compromise or not, we cannot judge our forebears too harshly for the errors incurred during the initial 1922 restoration programme as ship restoration and interpretation of this magnitude had never before been conceived let alone put into practice. Accepting this salient point, the *Victory* albeit not 100 per cent authentic, effectively became the 'teething ring' of all later historic ship preservation projects both on a national and international scale.

As a result of this undertaking we have today such ships as: the frigates *Trincomalee* and *Unicorn, USS Constitution* and *Constellation*; mercantile vessels such as the *Cutty Sark* and *SS Great Britain*. I have here omitted the equally important archaeological finds such as the ancient Egyptian royal barge belonging to Khufu (Cheops), various Nordic vessels, the Swedish 17th century warship *Vasa* and our own Tudor *Mary Rose*, the reasons for which relate to 'conservation' rather than 'restoration'. More recently restoration has been guided towards the 'metal' ships; *H.M.S. Warrior* and *Gannet, Minerva, Belfast,* and *Cavalier,* not forgetting various submarines. This list is not exhaustive for it does not reflect the myriad of small craft seen around our coast, or other projects be they large or small, local or world wide.

The subject of the *Victory* has perhaps been overwritten and definitely over modelled irrespective of accuracy. Much has also been published since 1922 [2] covering Naval architecture, construction and rigging of such ships in addition to the established works of Deane, Sutherland, Stalkaart, Murray, Steel, Peake, Fincham, and Charnock. [3] The objective of this thesis is to analyse what influenced the alterations made to the *Victory's* design, construction and appearance from her designer's conception on the drawing board to circa 1825, the last pertinent date before her present 1803-05 reconstruction.

To re-iterate it could be asked: What more is there to know about the *Victory,* surely this subject has already been over written ? For the past three quarters of a century the ship has, to a degree, retained some innermost secrets. In truth, re-evaluation of the evidence indicates that we do not fully comprehend the entire subject, all too often our understanding relates to the written sources of the period and that the real evidence faced before us has been ignored. To add, besides the contemporary works published between circa 1760 and 1850, our current interpretation primarily revolves around the host of existing papers produced by the Admiralty and the Navy Board. Though these documents are a valuable resource, neither these or the contemporary publications provide a 'coal face' bearing on the subject.

Modern methods of archaeology need to be applied. This is evident from projects like the *Mary Rose* which fortunately has been subjected to the full archaeological treatment much dictated by today's scientific approach to the object. Unfortunately for other ships under preservation, this school of practice has been somewhat neglected until recent years. Irrespective of the written source, which must not be discredited, undertaking detailed surveys is the only method of comprehending the true development of any particular ship, and the actual applied working practices governing it. Too much evidence is either lost or ignored during the restoration process in order to get the ship open to visitors or to eradicate decayed material. [4] Moreover, the other contributory factor relates to cost, be it either for quick financial return or restrictive in that it does not permit restoration to be undertaken in the correct manner. [5]

This is exactly what has happened to the *Victory.* To be fair, this fault cannot be directed towards the actual restoration team. Any failure in account for the academic approach lay primarily with the policies dictated by the relevant committees and the 'owners' policies, which in *Victory's* case are the Royal Navy and the Dockyard. Again, any criticism on this count is undue as the concept of addressing ship restoration together with archaeology was not an accepted policy until recent years. As a result, little remains of the original ship for us to analyse, the 'stable door being closed after the horse has bolted'.

This problem is further compounded by virtue that the ship had undergone several rebuilds during her active career, excluding her reconstruction during the 1920s. Naturally each time this happened, material, be it timber, copper or iron, etc. was removed from the ship and replaced with new, an acceptable fact for any ship in service. Obviously, a high proportion of what we consider as archaeological information simply disappeared. What is unacceptable is that once the *Victory* became an 'historical artifact' and conservation began, formalised recording should have been executed. More exasperating is the fact that timbers bearing builders 'rase' marks were initially destroyed. With them went crucial evidence that could have provided us with a better understanding of the actual methodology of 'on site' work practices. Irrespective of improved recording techniques employed during current restoration, the need for the dockyard shipwrights to complete deadlines leaves little time for archaeological record keeping. Likewise, though skilled in their craft, these shipwrights were not sufficiently trained in archaeological practices to undertake the task of carrying out historical analysis, and in reality, there was nobody else to do the job. Moreover, surveying the hull when the opportunity did arise, could not be fully executed as archaeological analysis in its present form is a relatively new science. Hopefully its application, albeit rather late, can still prove that there is much to learn from the *Victory.* [6]

In reality the hull of the *Victory* contains a spectrum of the various alterations made to ship construction and the corresponding industrial technology that evolved between circa 1760 and 1830. In this context, the aim of this paper is to demonstrate how, by careful analysis using archaeological disciplines, the supposedly silent timbers can speak. Not only does the fabric of the ship disclose a progression in wooden construction technique, it also presents to us, through application, the development and expansion of the iron, copper and alloy industries. Furthermore, it also shows the advances made in ordnance, a matter that relates to battle strategy and protection and subsequently ship design itself. In effect, the ship as an archaeological artefact reveals in microcosm, the broader world of reasoning, technology and industry on a national and international scale and the intercontinental policies that dictated the procurement and movement of raw materials.

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PART I.

Design Conception.

Chapter 1.

Design, Construction and Materials.

On the 13th December 1758 Parliament, under the leadership of Pitt the Elder, passed a Bill to build twelve new warships, one of which was to be a 1st rate of 100 guns. The proposed building programme was needed in order to expand the fleet to meet the demands of the intercontinental struggle with France known as the Seven Years War. The actual order for the construction of a new 1st rate ship was recorded within the minutes of the Navy Office 6 June 1759. [1] This decision was made after approval of the sheer draught also dated 6th June. In consequence the following instruction was given;

Sheer draught proposed for building a First Rate ship of 100 guns at H.M. Yard at Chatham pursuant to an order from the Rt. Hon. Lords Commissioners of the Admiralty of 13th December last and of the dimensions undermentioned viz.

Length on the gun deck - 186 ft.
Length of the keel for tonnage - 151 ft 3.5/8 in.
Breadth moulded - 50 ft 6 in.
Breadth extreme - 51 ft 10 in.
To carry on the lower deck 30 guns of 42 pounds
To carry on the middle deck 28 guns of 24 pounds
To carry on the upper deck 30 guns of 12 pounds
To carry on the after deck 10 guns of 6 pounds
To carry on the forecastle 2 guns of 6 pounds

Admiralty office
J. Cleveland
15th June, 1759.

After decisions had been finalised by the Government, the Navy Board directed the Commissioners of Chatham Dockyard to prepare a dock for this purpose. This instruction, which was implemented on the 7th July 1759, [2] read as follows;

By the Principal Officers
and Commissioners of his Majys. Navy.

Pursuant to the order from the Rt. Hon. the Lords Commissioners of the Admiralty dated the 13th December 1758 and 14th of last month, these are to direct and require you to cause and be set up and built at your yard a new ship of 100 guns agreeable to the draught herewith sent you and of the dimensions set down on the other side hereof, and you are forthwith to prepare and send us in due form an estimate of the charge of building and fitting for sea the said ship, and providing her with masts, yards, sails, rigging and store to eight months' proportion. For which this shall be your warrant. Dated at the Navy Office the 7th July, 1759.

Richd. Hall. *Tho. Slade.* *G. Adams.*
Th. Brett.

The keel was laid down in the Old Single Dock at Chatham on the 23rd July the same year. The site of this historic dock still exists today, albeit the dock has been extensively modified. The proposed 100 gun ship about to be built was not actually named *Victory* until agreed by the Navy Office 30th October 1760. This vessel was to be the fifth ship in the Royal Navy to bear this name. This name was probably chosen because 1759, the 'Years of Victories' or Britain's 'Annus Mirabilis', had become the turning point of the Seven Years War, the French being defeated at Quebec, Minden, Lagos, and Quiberon Bay. Her original elaborate figurehead, which was removed during her 1800-03 refit, ornately portrayed these events.

The overall design work was undertaken by Sir Thomas Slade who became the Surveyor of the Navy in 1755 once Anson had taken office as the First Lord of the Admiralty in 1751.

The fact that the order dated 15 June 1759 gives the *Length of keel for tonnage,* suggests that the draught for a yet umnamed 100 gun ship may already have been in hand. Although not absolutely essential for the purpose, a full draught makes the computation of the *Length of keel for tonnage* much simpler. *Length of keel for tonnage* could only be calculated from known dimensions these being: Length on the gun deck; extreme breadth; and height of the wing transom, the latter being taken from the upper side of the keel. [3] This point would not have applied prior to and during the legislation of the 1745 Establishment where all specifications were predetermined. Unfortunately, much to the embarrassment of the Navy Board, the 1745 Establishment had emphatically proved a failure within five years of its legislation thus it was now essential to depart from such rigid ruling if any form of innovative design was to progress.

The ship was completed a little under 6 years later, and 'launched' on the 7th May 1765. At this period, all 1st Rate ships were actually built within an enclosed dry dock, they being too large to construct in the conventional manner on a slipway; the *Victory* was not actually launched (in the broadest sense), but simply 'floated off' the dock. Initial construction work was overseen by the Master Shipwright, John Lock, but unfortunately he died in 1762 and was succeeded by Edward Allin. With the pressure of war it was expected to complete the ship within 30 months however with hostilities drawing to a close in 1763 the urgency to complete the *Victory* was less critical and work was reduced. Her overall cost amounted to £63,176. 3s. 0d. [4] Today this figure would equate to approximately 250 million pounds, the cost of building a capital warship such as a Through Deck Cruiser.

The design of any warship, whether it is constructed of timber, iron or steel, or a combination of these materials is related entirely to its desired function, or, to use an alternative phrase, must be 'fit for purpose'. Throughout history the criterion governing naval architecture principally remains unchanged inasmuch that it chiefly depends on the demands dictated by the pertinent nation and/or fighting ship owner. Furthermore these factors are also controlled by both the geographic environment in which the ship is operated, and the mode of fighting commonly used at the period. Irrespective of these factors, there are three fundamental elements involved in building a naval warship, each of which influence the end product which inevitably is usually a compromise of these attributes. The three factors are: Design, Construction and Material.

Design primarily relates directly to the 'combat' factor required of the vessel, offensive or defensive (in general, a combination of both). To expand, the concepts that lay behind the design of the ancient Greek Trireme and Bireme differ completely from those of the 18th century man-of-war. Likewise the principal requirements of vessels built during the Middle Ages, the 'longship' for example, are completely different from the two aforesaid ship types. Taking the Trireme as an archetype, the design of this form of vessel was such that according to Professor John Morrison its "seaworthiness was sacrificed to the requirements for maximum performance as a guided missile in battle". [5]

The sophisticated design of the Trireme is fully directed towards attaining the high speed, and impetus, necessary to pierce and sink enemy galleys with its integral built ram. Unlike any other warship (with the exception of a Fireship) the Trireme was itself the actual weapon, operated in the manner of a sea-borne 'lance' or 'dart'. To achieve this two design factors had to be accounted for: First, there was a ram which was fitted direct to the keel in order that the entire hull withstood impact: Second, the vessel had to be lightly built with a narrow beam which together with a shallow draught provided a small prismatic cross section where resistance was reduced to a minimum. The waterline length to breadth ratio of the recent built replica Trireme *Olympias* is approximately 1: 0.125. Compared to the medieval and 18th century vessels, (whose length to breadth ratio was about 1: 0.33 and 1: 0.28 respectively), the Trireme was a particular innovative design for its time. Trials carried out on the *Olympias* revealed that, under oars only, a speed of 6 knots could be achieved from a standing start in 30 seconds and a cruising speed in excess of 7 knots was easily attained, hence its effectiveness. Speeds of this magnitude were confirmed by Herodotus who recorded that one vessel covered 70,000 orguiai in a day. [6] This distance equates to 700 stadia or approximately 74 nautical miles. By calculation this provides an average speed of 7.37 knots for the hours of daylight the vessel was under oar. [7]

Unfortunately their light construction was only suitable to the native waters of the Mediterranean whereas more stoutly built vessels were necessary for Northern waters. To conclude, the Trireme was by design, suitably 'fit for purpose'. Primarily used in the offensive mode as an oar powered missile it was in reality a defensive weapon that could be rapidly called upon and launched from any shore to fulfill its role.

The 'raison d'être' of the 18th century man of war was to provide a 'stable floating fighting gun battery' and thus, by comparison to the aforesaid ship types, the ship of the line, was by far, a more complex machine. To expand from an eighteenth century viewpoint; *"A First rate ship, fully equipped and under way, this being beyond doubt the most superb engine that the mind of Man has ever conceived".* [8] Design was centered towards multifarious aspects before a draught was started. These principles, according to Murray, were; [9]

1. *To make a Ship carry a good Sail.*
2. *To make a Ship Steer well, and Quickly Answer the Helm.*
3. *To make a Ship carry her Guns well out of the Water.*
4. *To make a Ship go smoothly through the Water without pitching hard.*
5. *To make a Ship keep a good Wind.*

Besides good sailing qualities, speed and manoeuvrability, each of which were governed by underwater shape, other factors had to be considered. These were;

1. Large storage capacity; thus a ship could operate independently from base port for long periods.
2. Ability to withstand the onslaught of enemy shot in order to protect the ship's own gun crews.

To attain the above criteria the ratio between length, breadth and depth had to be carefully balanced together with a suitably computed keel length. For the *Victory* the relevant dimensions are as follows;

Length - 186 ft (56.73m). This dimension is taken on the level of the lower gun deck between the fore side of the rabbet at the stem post and after side of the rabbet at the stern post.

Breadth - 51 ft 10 ins (15.8m). This dimension is the extreme breadth measured from the outer face of the ship side planking at the widest point.

Depth - expressed as 'depth in hold' is in this case 21 ft 6 ins (6.56m). This dimension was measured between the underside of the lower gun deck planking to the upper surface of the 'strake next the limbers'. Realistically this figure was an 'artificial' figure used for calculating capacity when determining contracts and does not reflect the true depth of the hull between the load water line and the base of the keel. The quotient given does not account for the depth of the keel, false keels, and floor timbers, and thickness of the limber strake. Dimensions for these components are;

		ft.	ins.	
Keel	-	1	9	
1st False Keel	-	0	6	
2nd False Keel	-	0	4	
Floor Timber	-	1	11	
Limber Strake	-	0	6	
Total Depth	-	**5**	**0**	**(1.53m)**

To this add the following;

'depth in hold'	-	21	6	
Height between underside of lower gun deck plank and port sill	-	2	9	
		29	**3**	

To this subtract;

Height between gun port sills and load waterline	-	5	3	
Total		**24**	**0**	**(7.32m)**

This figure closely equates with the actual draught: 22 ft (6.71m) afore and 24 ft (7.32m) abaft, the mean being 23 ft (7.02m) and thus a true representation of the real depth.

Keel Length - all draughts provide a 'length of keel for tonnage', which again is an 'artificial' working figure employed to determine a ship's tonnage for contract purposes. It does not fully relate to the actual physical length of the keel. The true length of the *Victory's* keel, (dimension taken off the draught) measured from the back of the stern post to the fore part of the boxing, is 166 feet* (50.63m). This is often referred to as the 'tread of the keel'.

From these figures the relationship between length, breadth and depth can be determined, these are;

Length to Breadth = 1: 0.28.
Breadth to Depth = 1: 0.44.

In approximation these proportions are 1/3 and 1/2 respectively, quotients that correspond to those authorised some 140 years earlier, evidence stating; '*....for the depth must never be more than half nor less [than a] third thereof and the length never less than double nor more than treble the breadth'.* [10] Evidently a suitable set of proportions formulated on experience had long been determined to attain a reasonable compromise between stability, capacity, speed and manoeuvrability for sailing warship design. Any alteration made between the relative ratios would greatly effect the overall performance and requirements of a ship. In short this means;

<u>Change in Length:</u> Increase = Greater hogging and sagging problem.
Effectively reduce proportional breadth (see below).
Reduce manoeuvrability.
Decrease = Reduce hogging/sagging problem
Improve manoeurability.

<u>Change in Breadth:</u> Increase = Improved righting motion thus less rolling; greater stability for ordnance.

Decrease = Greater instability; righting motion and metacentric height compromised.

<u>Change in Depth:</u> Increase = Greater buoyancy; lower centre of gravity.

Raising of metacentric height; greater righting motion.

Greater stability for ordnance:

Greater capacity.

Decrease = Less buoyancy; higher centre of gravity.

Reduction of metacentric height thus greater instability;

Reduced capacity.

In addition to the above, the ratio between the ship's length (186 ft or 56.73m) and the length (or tread) of the keel (166 ft or 50.63m) has to be considered. This computes to 1: 0.89 which by comparison to ships built to the 1719 Establishment is greater. [11] This is mainly due to a reduction of the rake angle of the stern post introduced c.1750. Prior to this date the rake was considerably greater. (see Table 2/3 Chapter 2). This modification improved steering as the rudder acted more efficiently when hung close to the vertical plane. To facilitate this the heel of the stern post was moved aft. If the alternative alteration was made, e.g. moving the head of the post forward, gun deck length would be reduced. In effect there is a marked change after 1750. This fact is expanded further in Chapter 2. Alterations had also been made to the angle and curvature of the stem post the purpose of which was to accommodate greater support to the foremost ordnance. This again affected keel length though not significantly.

The other main factor that influenced buoyancy and stability was displacement which was given in Tons Burthen. Again this figure was attained primarily for contractual requirements and was determined as follows;

$$\frac{\text{Length of Keel for Tonnage} \times \text{Extreme Breadth} \times \tfrac{1}{2}\,\text{Extreme Breadth}}{94}$$

$$\frac{151\text{ ft }3.3/4\text{ins} \times 51\text{ ft }10\text{ ins.} \times 25\text{ ft }11\text{ ins.}}{94}$$

$$\frac{151.302\text{ ft} \times 51.833\text{ ft} \times 25.92\text{ ft.}}{94}$$

$$\frac{203275.96}{94} = \mathbf{2162.\ 51/94\quad Tons\ Burthen}$$

This however did not really reflect the actual capacity of water displaced, finding this measurement was at the period a very convoluted mathematical exercise which, due to its complexity, is omitted here to retain brevity. Examples of the pertinent calculations are clearly laid out in works by Steel [12] and Rees. [13] Close inspection of Steel reveals that this work, albeit with considerable additions, is based on an earlier anonymous work, the *Shipbuilders Repository,* published in 1788; in places Steel has copied whole passages verbatim. Likewise, Rees is virtually a copy of Steel.

Understanding the underwater shape of a vessel was very important. Though vessels having a deep draught and greater breadth tended to be slower, they potentially pointed (steered) well and sailed better when close hauled. At best most square rigged ships could steer 5.1/2 points (62 degrees) off the wind. The *Victory* herself sailed about 6 points (67.1/2 degrees) under reasonable conditions. Another point that proved important was where the greatest breadth was disposed, i.e. the 'dead flat'. Ideally this was either placed at the centre of length or a little before it. The latter was considered best as with a fuller bow the ship divided the water better then, by virtue of her underwater lines aft, provided a smoother run towards the rudder thereby attaining more effective passage through a fluid and improved steering. This point is expounded fully in Chapter 2.

Turning to construction, building technique had by 1759 reached a particular zenith inasmuch that experience dictated the basic principles. Though constructed after the 1745 Establishment much of the scantlings and dimensions applied to the *Victory* correspond to the Establishment specifications. Moreover some dimensions also relate to those found in the Shipbuilders Repository circa 1788, however this is quite probable because the ship was repaired shortly before. Analysis today shows a complex variety of specifications primarily as a result of many repairs and rebuilds.

In brief construction was as follows: First the keel, which formed the 'backbone' of the vessel, was laid. This comprised six lengths of straight elm 21 inches (53.34cm) square in section carefully scarphed and bolted together. The length of the scarphs were to be no more than twice the 'room and space'; i.e. 5 feet 6 inches (1.66m). Fitted on top of the keel was the hog or rising wood made from oak. Being made slightly wider than the keel, this acted as the seating for the frames that provided the body shape of the ship. The hog rose in height at the extremities forming the deadwood, that at the after end in effect formed a knee to support the stern post.

Next the stern post together with its inner post, wing transom, fashion piece and associated transom beams were integrally fitted together and erected in one component forming the aftermost boundary of the hull. A ship of this size would require a single oak tree to make the stern post. The heels of the stern and inner posts were tenoned into the keel. Likewise the stem post, manufactured from selected pieces of compass oak, was raised up at the fore part of the keel to form the foremost boundary of the hull. Its heel was located to the fore part of the keel with an intricate scarph called the 'boxing'. For additional strength the inner side of the stem post was supported with a secondary stem, also made from oak, called the apron. This was further backed by the stemson which itself was a continuation of the keelson.

The frames, or bends that dictated the actual hull form were next fitted. All square frames were fitted at 90 degrees to the keel and thus subsequently lay in the transverse plane. The foremost and aftermost frames were actually cant (angled) to coincide with the turn of hull curvature at each extremity. Much design work was required to ensure that the shape produced provided good underwater lines specially at the fore and after ends where hull entry and exit gave the least resistance to water without detriment to the other design requirements; buoyancy and capacity. Frames are categorised into two groups: Main frames and filling frames. The former comprised 13 pieces as follows; [14]

a. One Floor.
b. Two 1st Futtocks.
c. Two 2nd Futtocks.
d. Two 3rd Futtocks.
e. Two 4th Futtock
f. Two Toptimbers
g. Two Lengthening Pieces.

In effect a main frame was a series of separate timbers fayed and bolted together to produce a double thick timber. One half comprised a floor, two 2nd futtocks, two 4th futtocks and two lengthening pieces. The other portion consisted of two 1st futtocks, two 3rd futtocks and two toptimbers. The disposition of each main frame was such that it formed either the fore or after boundary of the gunports at each deck level **(Fig. 1/1)**. To determine this each frame was set along the keel at a predetermined 'room and space' (approx. 2 ft 9 ins or 0.83 m), this dimension however diminished towards the fore and after ends in order to joggle in the cant frames.

General practice directed that there were two filling frames fitted equidistant between each main (or double) frame. The components that made up a filling (or single) frame varied according to its location. For simplicity the filling frames will be called A and B, the former being 7 pieces, the latter 6, the sum of which amounted to 13 parts which collectively formed a main frame as discussed earlier. Components were as follows; [15]

Filling Frame A.

a. One Floor.
b. Two 2nd Futtocks
c. Two 4th Futtocks
d. Two Lengthening Pieces

Filling Frame B.

a. Two 1st Futtocks.
b. Two 3rd Futtocks.
c. Two Toptimbers

As can be seen from the above table each were half of a double frame, and so disposed that each dictated an image of its adjacent main frame. Above the waterline filling frames would be terminated in wake of gun ports sills and then continued above the respective lintels **(Fig.1/2)**.

Of note, a recent survey of the *Victory* has revealed that filling frame disposition differs from accepted practice. It was found that there were <u>three</u> filling frames fitted between the main frames in wake of the middle gun deck ports as opposed to the common <u>two</u>. This corresponds on both sides of the ship. Whether this practice was a result of a later repair or originates from 'as built' has yet to be decided however recent investigation has revealed that some of these timbers probably pre-date her 1800-03 refit. [16] The only other instance where a third filling frame was employed is at the 'dead flat' where it may have been necessary to adjust frame spacing in order to attain conformity of 'room and space'.

Furthermore frame disposition, irrespective of type (main or filling) altered in the fore and after body of the ship. Those fitted in the fore body had their floor timbers set afore and those in the after body abaft. The division between the fore and after body was denoted by the 'Dead Flat' indicated on the draught by the symbol ⊕. The dead flat was the frame placed at the greatest breadth. In many cases the frame at the dead flat was of the single type with either main frames or single frames either side. Again this was dictated by the 'room and space'.

Most of the framing was prefabricated before setting up and once all were set up in position the entire assembly was integrally locked together by fitting a longitudinal Keelson. On *Victory* the keelson is made from 6 pieces of straight oak 19 inches (48.26cm) square. To ensure strength, all keelson scarphs were set giving shift to those of the keel. By this period it had become practice to bolt all frame floor timbers through both keel and keelson. The extremities of the keelson were extended with a stemson forward and sternson aft. The framing of the ship was completed by fitting the stern timbers above the wing transom and the hawse pieces forming the bow of the ship and the beakhead bulkhead. Irrespective that fore and after areas rendered a potential weakness in warship construction; i.e. easily penetrated by enemy shot, design was at this period very much entrenched in conservative tradition. These points will be expanded further in Chapters 2 and 7. Once all the framing of the ship was complete the entire structure was temporarily secured with battens called harpins and ribbands and left to 'stand in frame' for one year. This period permitted the timbers to season and also permitted implementing any adjustments if necessary.

Though the practice of 'standing in frame' was conceived as the best policy to ensure that a hull was well seasoned before planking was applied there were some drawbacks. This related to distortion of hull framing and premature decay, a problem that was primarily due to geographical location together with climatic conditions rather than ignorance. All depended on the relative orientation of the building slip to the sun and prevailing winds. Observations revealed that many ships built at Deptford, Chatham and Portsmouth were found on launch to be lopsided. It appears that they *"did not swim upright; and it is certain that one side of them decays sooner than the other"* [17] To expand, ships built at Deptford, where radiated sun heat and wind action acted more profusely onto the larboard (port) side of the hull, the completed ships tended to list to starboard. At Chatham and Portsmouth where the geographical orientation differs, the problem was reversed. [18] In short a ship dried out quicker and subsequently became lighter on the side of the prevalent heat source. Obviously, to counteract this inherent problem, more ballast was generally placed on the 'lighter' side of a ship. Oddly enough, the *Victory* was given more ballast on her larboard side when first launched, and not the starboard side as would be expected. [19] Why this was so is still to be investigated. Obviously the ship is symmetrical so this should not alter the ballast distribution. The only theory raised so far is that for some reason the timber used on the starboard side was denser but why this should be so is unclear especially when one accounts for the weight difference of ballast used.

Completing the hull not only involved hull and deck planking, it also included fitting beams, knees and other internal strengthening timbers such as riders, etc. Though the planking formed the 'skin' of the ship some particular groups of strakes also acted as longitudinal strength members. This not only braced the hull together but also counteracted potential hogging and sagging, problems pertinent to most wooden ships. Consider the hull as a single beam, hogging is the tendency for the beam to droop at its extremities, while sagging relates to the drop of the beam along its centre of length. It was virtually expected that the hull of a standard man of war would hog 6 inches when it took to the water. Externally the *Victory* was constructed with three heavy bands of plank called wales; main wale 10 inches (25.4cm) thick, middle wale 9 inches (22.9cm) and channel wale 8 inches (20.3cm) thick. One of these was set below each row of gun deck ports. The wales were built with a pronounced sheer rising towards the extremities of the hull in order to counteract the hogging and sagging effect. Between the wales the ship was planked up with boards of lesser thickness. Below the main (lower) wale the ship's bottom was planked with diminishing strakes, bottom plank and a garboard strake adjacent to the keel.

Internally the hull is longitudinally braced with heavy bands of spirketting varying between 7 and 4 inches (17.8-10.2cm) thick, and deck clamps (beam shelves) at each gun deck level. The spaces between were lined with thinner boards called 'quick work'. Below the main gun deck is a series of stringers called 'thickstuff' that are wrought over the scarph joints of the frames, the lowest, which runs parallel to the keelson, being the limber strake. The spaces between the thickstuff are lined with bands of footwaling and the thinner ceiling.

Transversely the hull was braced with deck beams supported at their extremities to the ship's side with vertical hanging knees and horizontal lodging knees. Many of the hanging knees were later replaced with beam end chocks integrated with iron plate knees (See Chapter 7). Intercostally worked between the beams were longitudinal carlings and transverse ledges. Further transverse support was given with the aid of deck and breast hooks, crutches and sleepers while in the hold were riders, internal frames that ascended to just below the lower gun deck. Finally longitudinal strength was added by laying the deck planking.

All fastenings were of either iron or copper bolts, treenails and iron spikes (nails). The bolts themselves were in effect only metal rods driven through pre-drilled holes and clenched over roves and consequently could work loose under certain conditions. As can be seen the entire structure relied entirely on longitudinal and transverse construction which itself incurred considerable weaknesses with respect to limited lines of stress loading when the ship endured labouring in heavy seas. This, together with relatively weak or ineffective fastenings and inherent rot problems, limited a ship's durability. Deficiencies of this form were, to some degree, being analysed by Thomas Slade and his contemporaries however it was to be a few more decades before innovative changes in construction and designs were implemented. This was chiefly done though more thorough investigation by such persons as Gabriel Snodgrass and Robert Seppings, each of whom in turn would influence the development of the *Victory* during her career.

Considerable material was required to construct a first rate ship. Timber used for building the *Royal George,* launched 1st February 1756, amounted to some 5760.1/2 loads, a load being 50 cubic feet. [20] From this the actual capacity of timber used <u>before conversion</u> is estimated as 288,025 cubic feet. [21] Furthermore the weight of one load averaged about one ton (1.016 tonne). Since the *Royal George* was marginally smaller than the *Victory* it can be reasonably estimated that some 300,000 cubic feet of timber went into *Victory's* construction. It must be noted that 1 acre, which yielded about 40 trees, could produce about 60 loads after a period of sixty years. [22] This amounts to 3000 cubic feet which equates to 1% of the timber needed to construct the *Victory.* By simple rule of thumb it can be stated that a ship required 1 acre for every gun borne.

Building material at this period comprised Straight Oak, Compass Oak, Dantzic Oak, Elm, and Fir. By calculation the percentages of timber used in comparison to capacity before conversion are as follows;

English Straight Oak	-	44.64 %
English Compass Oak	-	45.60 %
Dantzic Straight Oak	-	3.75 %
Elm	-	2.32 %
Fir		3.70 %

The above figures are derived from timber tables given for each class of ship by Charnock. [23] Though figures are based on the *Royal George*, inspection reveals that percentages vary little between any 1st, 2nd or 3rd rate ship of the line.

As seen, some 94% of the construction material comprised oak albeit English or imported timber. This figure later decreased as lighter weight Dantzic or Prussian Deal or Fir became more prevalent for deck planking towards the end of the 18th century. [24] With disregard to the lower gun deck, which remained entirely planked in oak, it became common practice to use oak only for waterways and adjacent to coamings on other decks. Not only did this change reduce weight and expense it also served to conserve the more valuable oak which was fast becoming scarce. The ratio between English and imported oak was also to alter towards the end of the century. Elm was primarily used for keels, garboards and lower strakes of bottom planking. Other uses were limited to fittings which related to water such as brake pumps, chain pump cisterns and pump dales. Fir was used for various applications where strength was not such a premium such as bulkheads, sheathing boards (see Chapter 6) and later for deck planking. In the interests of conserving oak and expense experiments were also made by building frigates entirely of fir. Five 28 gun frigates, based on the lines of the *Unicorn* class, built of this material were ordered as part of the emergency building programme in 1756. [25] These ships were not however entirely successful. With the exception of the *Hussar*, which was captured, the remainder, *Boreas, Shannon, Actaeon,* and *Trent* were all sold off within 7 to 13 years as 'unservicable'. [26] In addition other timbers used were ash and beech, the former for tillers and capstan bars, the latter for filling pieces and minor works.

English oak (Quercus quercus or Quercus peduncalata) used for the *Victory* was procured from Kent and Sussex. Trees indigenous to the Weald were particularly good due to the heavy clay soil which promoted slower growth producing a close grained tougher timber. Oak grown in less suitable ground; e.g. low lying marsh, promoted various deficiencies such as rapid growth, long open grain and subsequently weaker and rapid decay. [27] It was not so much that English oak was the most suitable ship building material against other types of oak moreover that it was more readily abundant. Foreign oak such as Baltic, Italian, Prussian [Danzic] Canadian and American, were equally preferable but their supply could easily be constrained by war or other unforeseeable trade difficulties. Some imported timbers were also inherently inferior. Baltic oak, better used for wainscot, was not fit for planking due to its spongy sap wood. This was generally caused by excessive frost. [28]

Of the most suitable North American oaks, Canadian White oak (Quercus alba) and American Red Oak (Quercus rubra), were subject to decay within 5 years. [29] The only exception was Live Oak (Quercus virens and Quircus semper virens) which, native to Florida, proved a very superior material. Two examples of ships built with live oak are the frigates *USS Constitution* launched in 1797 (still in existence) and the *Essex*. Of the former, the fact that this ship is still afloat today leaves little more to say. Regarding the latter ship mentioned, it was found that twelve years after her launch, only six defective timbers were found from the original 507 pieces used in her construction. [30]

The most suitable trees selected for use of 'straight oak' were about 100 feet (30.5m) high and had a girth of between 12 and 50 feet (3.66 to 15.25m). 'Compass oak', ideal for the curved futtocks that formed the frames of the ship was usually selected from shorter oaks growing in hedgerows. The best timber was obtained from trees felled when between 70 and 100 years old. This point was well clarified by the classical writer Pliny who stated, *"To have good timber, the trees should be cut down that are of middle age, for neither young poles nor old runts are fit for durable building".* [31] Seasoning was also very important thus much of the wood used for the *Victory* had been selected and left to air dry for 13 to 15 years before build.

Elm (Ulmus procera), a wood primarily indigenous to England, was suitable for use where timber needed to withstand damp environments or long immersion in water. Trees of this type grew to similar proportions but *"in less than an age"* [32] to that of oak. As stated previously, elm was primarily used for the keel, not only for its natural inherent properties but its irregular grain permitted the intrusion of many bolts without splitting. It was also common practice to fit about ten strakes of elm planking from the garboard upward on the ship's bottom. The other property associated with elm was that it could withstand a certain degree of shock and not was easily fractured when knocked. For this reason it was also used for the manufacture of rigging blocks. This timber was also adopted for making pump dales, cisterns and capstan whelps. With regards to pumps, it had long since been observed that the common decay of severed boughs remaining on a tree produced natural conduits, a point readily adopted by man for pipes, etc. [33] Wych Elm (Ulmus glabra) was used for thinner planking especially with for small boat construction.

The Fir used, though common to the same family (Pinaceae), would have varied depending on source: Silver Fir (Abies alba) and Norwegian Spruce (Picea abies). [34] As stated before the practice of laying fir deck planking on uppermost decks was becoming more common in the second half of the 18^{th} century, mainly due to its lower weight and cost. This timber was also used for internal bulkheads subdividing the hold, the magazines, and the various compartments fitted on the fore and after platforms of the Orlop. Thin boards of fir were also employed for sheathing the bottom of the hull prior to the introduction of copper (see Chapter 3).

Pine was also necessary for manufacturing masts and yards. Most timber required for this purpose was, at the time of *Victory's* build, imported from the New England colonies. The timber trade which supplied the Royal Dockyards from this part of the globe had flourished since 1652. The accession of William and Mary in 1689 opened up hostilities with France. As a result a sustained programme of naval expansion was introduced thus the demand of timber from this quarter increased. To ensure continuity of supply a Broad Arrow Policy was passed which controlled colonists rights regarding timber activity. This policy was vigorously implemented between 1691 and 1729 and remained in force until the American War of Independence in 1775. [35] England's rights on mast timber were a highly contentious issue surrounding the colonial grievances leading to the war. After this date the Broad Arrow Policy continued in Canada only, [36] while elsewhere alternative supplies were sought, the Baltic becoming the predominant source.

On matters of mineral materials, iron, copper, and mixed metal (bronze), etc., sources were variable and often subject to the influence of war or politics. The best iron was generally imported either as natural ore or cast ingots known as pigs. The best quality, colloquially named Orgrounds Iron, was imported from Sweden. This was found more suitable for the production of wrought iron and the manufacture of steel. Alternative supplies, other than native iron, were imported from Spain or the American colonies. To expand on the latter, it must be remembered the Iron Act of 1750 prevented the colonies producing their own iron goods. By 1761 overall imports of iron for national use amounted to some 47,250 tons (48,006 tonnes) this being 3,000 tons (3,048 tonnes) of pig iron from the colonies, and approximately 44, 250 tons (44,958 tonnes) of bar iron from other countries. [37] With Cort's innovation of the dry puddling process in the 1780s (refer Chapter 13), where low quality English iron could be made into high quality malleable wrought iron, the necessity to import iron was reduced. Irrespective of iron manufacturer, iron was supplied to the Navy by contract. Though there were various contenders, the primary tender appears to have been executed through Andrew Lindgren and Company of London. [38] Cast iron ballast was supplied through either David Tanner of Monmouth or Richard Parsons of Cadoxton-juxta-Neath, Glamorgan. [39] Obviously, as industry expanded, much spurred by Watt and Cort, the supply of iron to the Navy extended to cover multifarious sources.

Primarily there was little requirement for copper and other non-ferrous metals thus supply was less concentrated, however when copper sheathing was introduced for both Naval and Mercantile shipping during the 1780s demand increased dramatically. At about the same period the copper industry expanded to such extent that Britain monopolised the international market at this period. This was mainly due to the industrialist Thomas Williams whose entrepreneurial leadership amalgamated the various companies. [40] The main source of copper ore was obtained from the mines of Parys and Mona in Angelsey, alternative supplies being obtained from Cornwall. Smelting was generally undertaken in South Wales, [41] Initial supplies to the Navy were made through the agents Gnoll Co., from the Royal Mines Co. at Neath, and from Charles Roe and Co. of Macclesfield, the main contractor being William Forbes of Deptford. [42]

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Fig. 1/1. Main and Filling Frames.

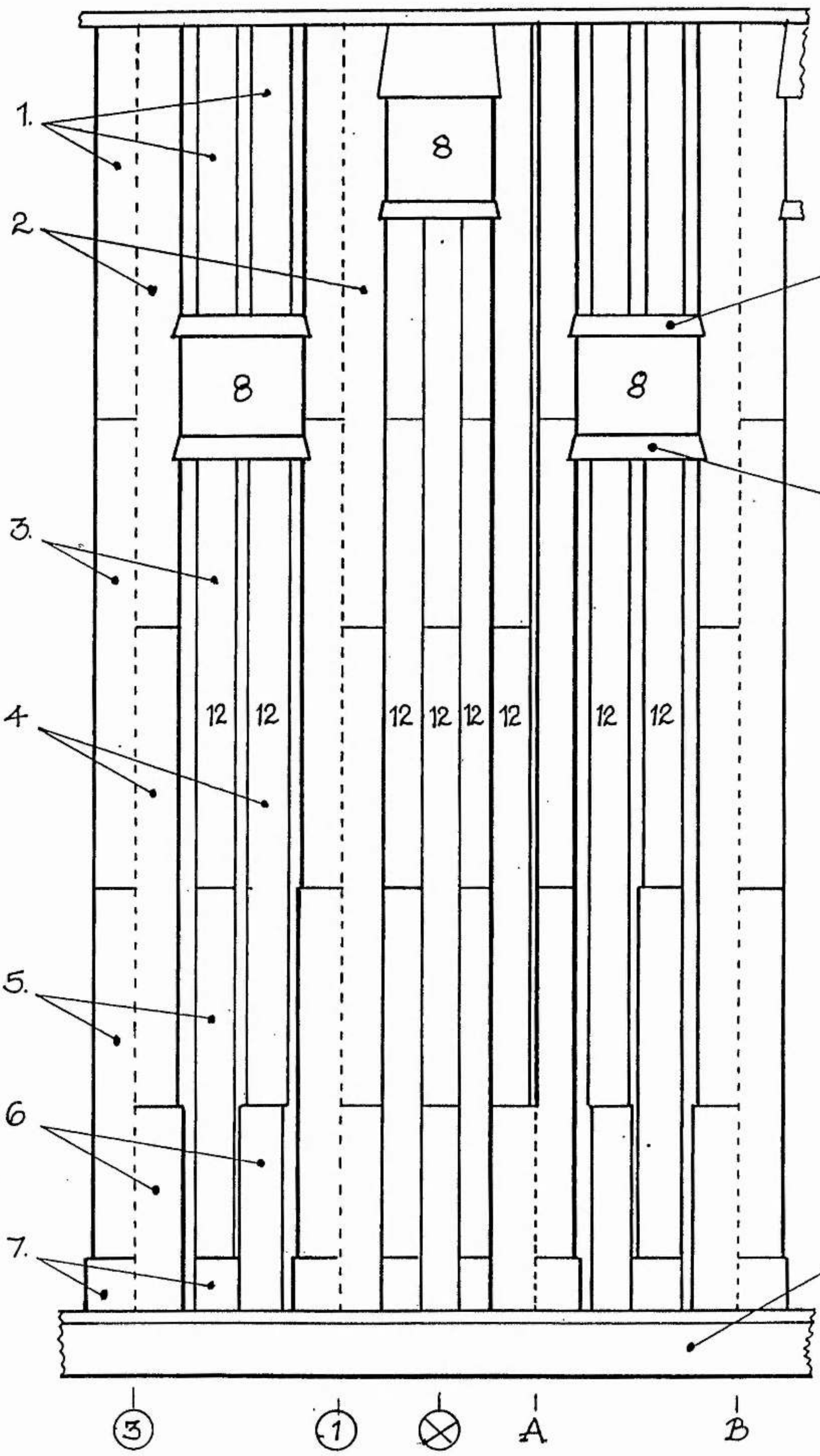


Figure 1/1. Main and Filling Frames.

Key:

1. Lengthening Pieces.
2. Toptimbers.
3. 4^{th} Futtocks.
4. 3^{rd} Futtocks
5. 2^{nd} Futtocks.
6. 1^{st} Futtocks
7. Floor Timbers.
8. Gun Ports.
9. Port Lintels.
10. Port Cills.
11. Keel.
12. This figure denotes all Filling Frames.

3 2^{nd} Main frame in the after body of the ship.

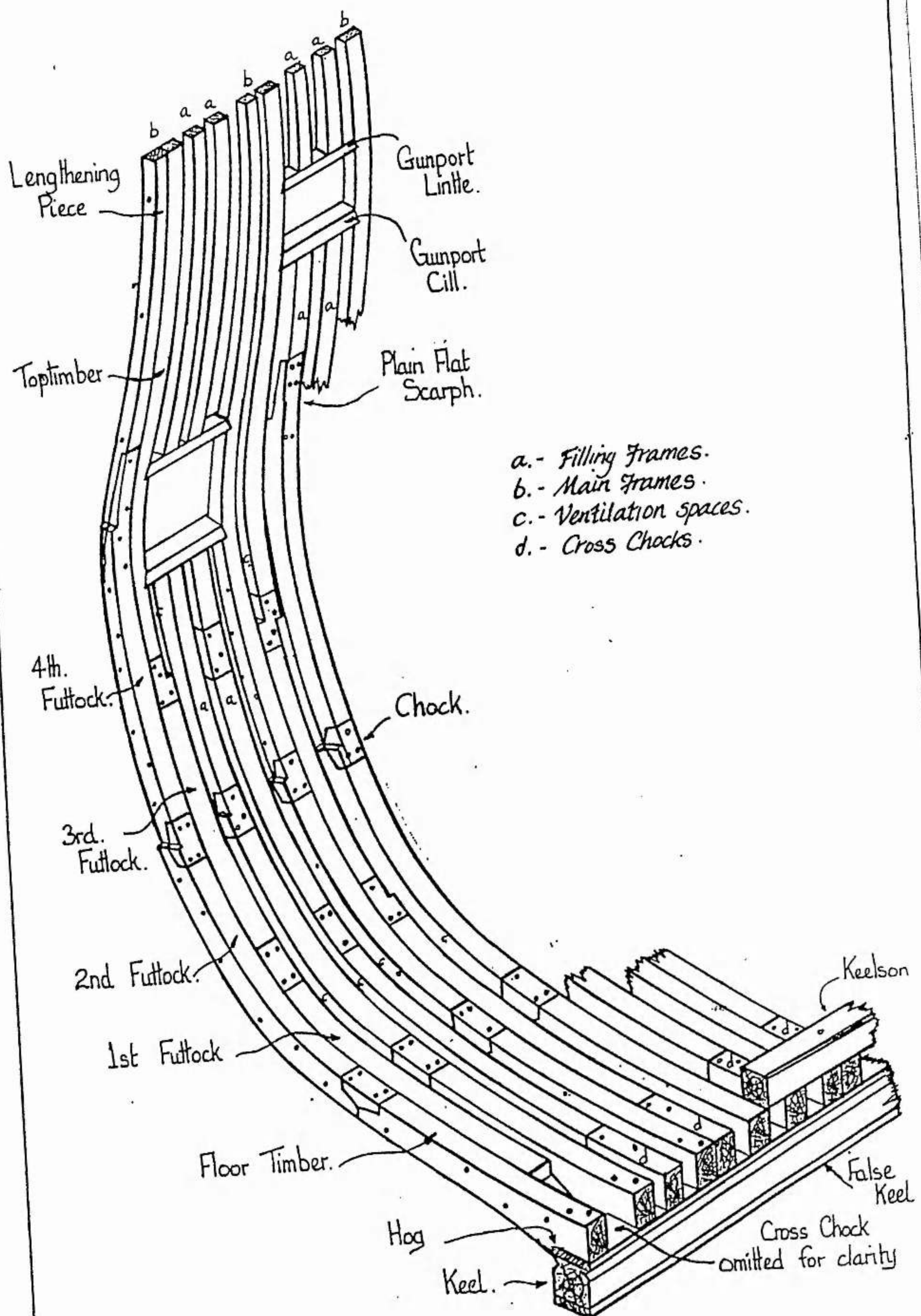
1 1^{st} Main frame in the after body of the ship.

Ø Dead Flat (point of extreme breadth).

A 1^{st} Main frame in the fore body of the ship.

B 2^{nd} Main frame in the fore body of the ship.

Fig.1/2. Frame Construction (74 Gun Ship).



Chapter 2.

Slade the Designer and the Influence of French Construction.

The *Victory* was initially designed by Sir Thomas Slade (1703/4 -1771) who, jointly with William Bately, had replaced Sir Joseph Allin as Surveyor of the Navy in 1755. Slade, though originally a humble shipwright, had come from a distinguished shipbuilding family. Family namesakes were Benjamin, Second Assistant to the Master Shipwright at Plymouth in 1740, William, an overseer at Kings Lynn and Ipswich in 1741, and a second William, a shipwright at Bristol.[1]

By 1742 Thomas Slade was already established as the Master Shipwright's Assistant at Woolwich Dockyard and was also employed designing a harbour at Sandwich. In 1764 he forwarded a new design for Sheerness Dockyard but this scheme was shelved due to the discovery of the shipworm 'teredo navalis' [2] (refer Chapter 3: Copper Sheathing and Fastenings). Making his name as a shipbuilder and designer Slade quickly rose to the post of Master Shipwright at Deptford. [3] Slade's abilities were soon recognised by Lord Anson who had served on the Admiralty Board since 1744. It appears that Anson and Slade jointly worked towards proposing revolutionary concepts of ship design that effectively vanquished the constricting authority of the Establishments since their introduction in 1706. Much criticism has been made regarding the Establishments especially towards their conservatism which restricted scope for inventiveness. Irrespective of this view, the initial reasons for their introduction must be fully understood. The main aim of the Establishments was to attain uniformity within each rate or ship type and to maintain the principles established by experienced shipbuilders. Second, by standardising equipment sizes, the supply of stores, masts, etc. could be ensured. The notion that lay behind the Establishments was not an entirely new concept for the French, under the administration of M. Colbert, had introduced a similar system some 20 years earlier than the English for the same reasons. Similarly, the French also abandoned the system due to the constraints imposed, again earlier than the English.

The initial credit for the progressive work undertaken by Thomas Slade cannot be fully attributed to him alone as much was influenced by Benjamin. In effect both were working directly under Anson. In short Benjamin Slade was taking lines off captured French vessels and passing them to both Thomas Slade and Anson. From these actions new design concepts were introduced.

During his tenure as Surveyor of the Navy (1755-1771), Slade was responsible for designing 181 ships, the types, names, and date of launch are given in Appendix I. Much influenced by the dimensions of French warships Slade became instrumental in the introduction of new class types, size increase and capabilities of British men of war. The *Romney*, a 50 gun ship laid down at Woolwich during the same year as the *Victory*, was a fine example of Slade design. This vessel, which was actively deployed for forty years, was considered a superb ship of her class. [4] Her dimensions were as follows;

Dimension	**feet**	**inches**	**(metres)**
Length on the Gun Deck	146	0	44.5
Length of the keel for Tonnage	120	8.1/2	36.8
Extreme Breadth	40	4.1/2	12.3
Depth in the Hold	17	2	5.23
Burthen in Tons	1046.1/94		
Proportion of Breadth to Length	1:3.61		

Between the years 1757 and 1760 a new class of 5^{th} rates frigates were introduced to the fleet, most designed by Slade. These included, three 36 gun ships, most of the thirteen 32 gun frigates and nineteen 28 gun ships. [5] The dimensions of the principal ships of each class were as follows; [6]

Table 2/1.

Name	**Guns**	**Launch Date**	**Length of Gun Deck**		**Length of Keel for Tonnage**		**Extreme Breadth**		**Depth in Hold**		**Burthen in Tons**	**Proportion of Breadth to Length**
			Feet.	ins.	Feet.	ins.	Feet.	ins.	Feet.	ins.		
Pallas	36	1757	128	4	106	4	35	11	12	4	728	1: 3.58
Stage	32	1758	125	2	103	8	35	10	12	0	706	1: 3.50
Argo	28	1758	118	6	98	1	33	11	10	6	601	1: 3.69

Note: Figures have been rounded to eliminate fractions.

Common consensus is that the design of the *Victory* is based entirely on English ship development and to suggest otherwise would be considered rather controversial. If however we are to analyse the fundamental issues influencing design at the period of her construction it is quite clear, irrespective of the irony, that the origins lay rooted with our adversaries across the Channel.

As previously stated, the Establishments authorised by the Navy Board were restrictive leaving little scope for improvement and inventiveness. This problem was very much due to Allin and Ackworth who, for many years, had jointly held the office of Surveyor. Both men were elderly and very conservative in their outlook, an attitude which reflected the general opinion of most naval shipbuilders holding office at the time. This fact was very soon highlighted by the Admiralty when it was soon realised that the 1745 Establishment was a failure. New ships being produced were to a degree crank and carried their armament too close to the waterline. Problems had also arisen due to little understanding of hydrodynamics inasmuch that the lines produced, especially those in the after body of the hull, rendered poor sailing qualities and inherent steerage difficulties. These points are evident from the many complaints submitted from sea officers. [7]

The French on the other hand had long since modified their approach to ship building. This revolution had commenced during the reign of Louis XIV under the innovative authority of his Minister of the Marine, Jean-Baptiste Colbert. [8] From 1671 Colbert systematically initiated a more scientific approach to ship design using the resources of mathematicians and applied technological skills. Such personnel were drawn from the Academie Royale des Sciences, an institute that was set up in the 1660s to serve both science and the crown. [9] One fact that must be clarified is that Colbert was well aware that the English shipwright Anthony Deane had recently developed a theoretical 'Doctrine of Naval Architecture' in 1670. Motivated by this concept Colbert used this as a measure to restructure the French fleet. To achieve this he called upon Admiral Abraham Duquesne, his *grande maitre des constructions*, to provide a similar doctrine, informing him that it was *"the most important business of the Navy"*. [10] Duquesne was also responsible for introducing the 'galiote a bombe' - bomb vessel which carried large mortars for coastal bombardment. This concept was the ingenious invention of the Basque, Bernard Renau D'Elicagaray. [11] In 1673 the first theoretical works relating to the behavior of bodies moving in fluids were published by the Jesuit Father Ignace-Gaston Pardies. [12] This work was later expanded by Paul Hoste in 1697 [13] which, though erroneous by a small degree, first established shipbuilding on a theoretical level. Also in 1673 Colbert introduced a 'reglement' that standardised dimensions and scantling's specification for five rates of ships. [14] This pre-empted a similar scheme, called an Establishments of Dimensions, which was later introduced in England in 1706 which continued, albeit amended on occasion, in use until 1745.

Later in 1683 Colbert directed that individual ship models where to be manufactured for training shipwrights and designers. [15] These models were of considerable size far exceeding the standard 1:48 scale Navy Board models made in England. Effectively the French had provisionally formulated a professional corps of naval constructors giving them a marginal advantage over their English counterparts. This concept was further expanded in 1741 by Henri Louis Duhamel Du Monceau, the Inspector General of the French Navy. Duhamel set up a training school, the 'Petite Ecole' where Chief Surveyors could sent their best students to study theoretical ship design. [16]

The limitations of English ship design and the constraints of the formal Establishments were soon ratified due to the capture of the Spanish 74 *Princessa* in April 1740. This vessel was found to be far superior inasmuch that it took three of our 70 gun ships (*Kent, Lennox,* and *Orford*) six hours to overcome her. As result, current specifications were reviewed and new Establishments were introduced in 1741 and 1745, the latter formulated by a committee led by Sir John Norris. Irrespective that standardisation was improved and that dimensions were marginally increased, the fundamental issues of design remained neglected.

To reiterate much criticism had already arisen regarding the specifications authorised in the 1745 Establishment, especially those related to the 80 and 24 gun ships. The former, which mounted their armament on three decks, were considered too crank and could only use their lower battery in very mild sea conditions. Unfortunately the initial proposals submitted by the Admiralty in favour of replacing these vessels with two decked 74s based on the French and Spanish designs had already been thwarted. In answer the Norris Committee stated that they were, *"sorry to differ with your Lordships therein, but having observed on many occasions the advantage which 80 gun ships with three decks had over those with two and a half, judged it for the benefit of the service that so useful a class should be continued."* [17] However the concept of the 74 was not fully dismissed. With regard to the 24 gun ships all were found to have poor lines especially in the after body.

On 3rd May 1747 Admiral Anson, flying his flag in the *Prince George* (90), captured the French 74 *L'Invincible* off Cape Finisterre. *L'Invincible* was the first of a new class of two decked 74 gun ships developed by France in the 1730s constructed under the direction of M. Maurapas, the Minister of the Marine. These vessels were part of his re-development programme aimed at increasing the capacity and capability of the French Navy since its demise after the Colbert administration. [18] This ship, built at Rochefort by Pierre Morineau in 1741, was launched on the 21st October 1744. *L'Invincible* and her sister ship the *Magnanime* were considerably larger and more expensive than previous built French 74s such as the *Duc d'Orleans* (1738) and *Terrible* (1739). Ships based on the *Invincible* design of the 74 gun ship were to become the predominant line-of-battle ship in both the French and English navies for the next 70 years. The original French *L'Invincible* class included the *Conquerant, Intrepide, Monarque, Sceptre, Florissant, Magnifique, Temeraire, Redoutable* and *Couronne,* [19]

On inspection Anson found that dimensionally the 74 gun *Invincible* (now re-named) was actually larger than his own 90 gun *Prince George,* and wrote to the Admiralty that the *Invincible* was, *"a prodigious fine ship, and vastly large. I think she is longer than any ship in our fleet, and quite new".* [20] Furthermore reports from later commanders, including Keppel, highlighted her remarkable sailing qualities. [21] Naturally with a longer hull she could, with a speed of 13 knots, out-sail any English ship of equivalent class. Moreover, her design was to have a far reaching impact on English ship construction.

In 1751 Anson was formally appointed as the First Lord of the Admiralty Board. Though younger than many of his predecessors he proved to be a superb administrator. Well aware of the shortcomings of the fleet, and unrestrained from the old conservative regime, he soon became the prime mover behind the development of English warship design. Using foresight he encouraged the most suitable people of the constructor corps such as Thomas Slade and William Bately into his organisation. Considerable influence was also provided from Thomas Slade's kinsman Benjamin who was currently serving as the Assistant Surveyor at Plymouth. In view of Anson's obvious intention to improve ship design it appears that each of these men were already supporting him outside the official channels of the Navy Board. Evidence supports the fact that Benjamin, working directly under Anson's private instructions, was ordered to construct a 24 gun ship based on the lines of the captured French privateer *Tyger*. Futhermore this information was also being directed to Thomas Slade. A comparison of lines was made between the *Tyger* and existing 24 gun ships which, as already pointed out, were badly designed. Bejamin reported as follows; [22]

My Lord

I have sent by the waggons (sic) *from Plymouth the draught of the* Tiger *french privateer taken by the* Falkland , *& the* Subtle *french man of war taken by the* Portland & Winchelsea, *and desired Mr Slade Assistant of Woolwich Yard to wait on your Lordship with them, have compared the common lines of those ship on the back of the draughts, also the 'sending and pitching lines of the* Tiger *with new 24 gunships of the master builders designs, which appeard* (sic) *to me very necessary for your Lordships consideration; the point of contact is in the middle of the ship at the main waterline in her sailing trim, afore the lower edge of the false keel is three feet under the surface, and abaft ranges up to the counter in a straight direction , which gives form to the lines compared, and by them seems to demonstrate the prodigious difference there is abaft, and little afore in those ships. I am strongly of opinion the present draughts of the 24 gunships are too ful* (sic), *and that the* Tiger *is as much the contrary, but withal her more certainly of going better to windward, and the other before the wind; We have laid* *down the body and molded most of the frame of the* Unicorn, *if we had men to go on with her would launch her before christmas, But the* Ipswich *and* Mars *repair, ships coming into refit, sheath fit the Bottom of the* Charles *and* Ruby, *I am afraid will prevent it. The* Mars *will be a good ship when done, little inferior to our own ships, and appear very agreable* (sic); *wil* (sic) *take off the Body of the* Two Crowns *as soon as we have a dock to put her in, and send your Lordship a true draught of her. I pray My hearty congratulations and your new dignity may be acceptable and ever attended with the most distinguishing marks of true merrit* (sic) *and a glorious conclusion; having tired your Lordship with my long epistle, I have only to ask pardon for doing so and to pray your Lordship wil* (sic) *give me leave to subscribe myself.*

Your most Obedient faithful
humble Servant

Plymouth Yard
21st July 1747

Signed (Benjamin Slade)

Other captured ships were also inspected and their lines taken off. As a result various new ship types, based on lines of the aforesaid captured French ships, were developed. These were as follows;

Table 2/2.

French Ship	**New Class Name**	**Rate**	**Guns**	**Date**	**Surveyor/Builder**
Tyger	Unicorn	6th	28	1747	Benjamin Slade
Invincible	Dublin	3rd	74	1748	Thomas Slade
Invincible	Valiant	3rd	74	1757	
Fougueux	Ardent	3rd	64	1761	Thomas Slade

Note: For clarity the French name *L'Invincible* has been altered to its English equivalent.

Dimensionally, French ships were also larger than their English counterparts thus we also see an increase in vessel size from this period. Irrespective that the French preferred to build ships of lighter construction for speed, the English concept was to design ships that would endure lengthy periods at sea upholding blockade duties. Thus although French lines were adopted the English practice of constructing ships with heavier scantlings primarily remained in order to accommodate these principles. As a result new designs were introduced, the major class being the 74 gun ship which was to form the backbone of the British fleet for the next 60 years.

Another influential factor was the manner in which draughts were drawn. The conventional practice was based on using the 'rising line', this however produced a marked hollow in the bows. Slade adopted the French practice of using the 'diagonal floor ribband' system. This method, which provided better scope for determining the bends of the frames, was first noted by Mungo Murray in his treatise published in 1756. [23] The French had successfully been using this system for the previous ten years [24] This fact is noteworthy inasmuch that Murray's work was directly based on that previously published by Duhamel du Monceau in 1752, [25] It would prove beneficial to determine how much Murray's work influenced Slade. Murray served as a shipwright at Deptford Yard.

French design also affected change to the angle of the sternpost. Close inspection of ships draughts dated from 1719 to 1783 reveals a distinct point of change circa 1750 (refer Table 5/2). Standard English practice was to have the sternpost angled at about 13 degrees, a feature that probably lay rooted in the design concepts indoctrinated by Sir Anthony Deane during the late 17th century. [26] The fundamental reason for this modification was to improve the torque of the rudder. Second, with the refinement of buttock lines aforesaid, the effectiveness of the rudder was greatly improved if hung nearer the vertical. Obviously this minor difference from English practice was quickly identified by Slade when inspecting the French ships at Plymouth Yard. Moreover, a more vertical sternpost provided greater support to the after end of the Gun Deck and subsequent stern construction above it.

Table 2/3.

COMPARISON OF STERN POST RAKE 1719 TO 1783.

Date	Establishment	Ships Name	Guns	Rake Angle	Surveyor
1 719	Yes	Britannia	100	13	Hayward
1719	Yes	Centurion	60	12	Allin
1733	Yes	Saint Albans	50	12	Lock
1741	Yes	Devonshire	80	12	Holland
1741	Yes	Newark	80	13	Ward
1745	Yes	Royal George	100	10	Establishment
1741	Yes	Kent	64	12	Ward
1741	Yes	Ramillies	90	16	Lock
1755	No	Dublin	74	3	Slade
1755	No	Sandwich	90	4	Slade
1759	No	Victory	100	5	Slade
1759	No	London	90	4	Slade
1771	No	Duke	98	4	Williams
1783	No	Caesar	80	4	Hunt

Note: As seen from above, there is a distinct change in Stern Post angle after c. 1750.

Other influences taken from the French relate to ironwork. Though listed within the 1719 Establishment onward, little iron work, other than bolts. etc., was employed in ship construction until the turn of the century. If used it was generally isolated to the fitting of standards which were inverted knees fitted between the ship's side and the deck. The French, on the other hand, had adopted the practice of fitting iron brackets in place of wooden knees far earlier. [27] Examples of such were found on the *L'Invincible* launched in 1744. The subject of ironwork is expanded further in Chapter 7. Other aspects, which derive from French origin, are highlighted within their respective chapters.

Although it appears that Britain extracted considerable technological knowledge from the French, the direction that information was transferred was not wholly one way. In the 1730s Blaise Gislain visited our Dockyards, [28] likewise, during the brief peace after the American Revolutionary War representatives from France often officially inspected our Dockyards and our manufacturing sites related to the Iron and Copper industry.

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Part II.

Technological and Structural Development.

Chapter 3.

Copper Sheathing and Fastenings.

Very little protective copper sheathing remains on the bottom of the *Victory* today with the exception of the entire rudder and isolated fragments at the keel, the details of which are covered later **(Fig. 3/1)**. Most of the sheathing had been removed during successive restoration work carried out from the 1950s onward and stored nearby. The last recorded date relating to sheathing the hull was when the ship was docked for emergency repairs between 20 December 1887 and 14 October of 1888. [1] To what degree copper was replaced is unknown but costs recorded appear to indicate that this was a large repair rather than a complete recovering. This is indicated by the fact that copper plates inspected reveal three separate manufacturers names. Some copper sheathing was probably replaced on the larboard side after the accident when the *Neptune,* which was being towed to the breakers, inadvertently rammed the *Victory* in 1903.

When first launched in 1765 the lower hull of the *Victory,* like all other men of war at the period, was sheathed with thin boards of deal to protect her from the ravages of the marine boring mollusc 'teredo navalis' commonly known as ship worm. Originally native to tropical waters this worm had, due to ships returning from the West Indies, etc., become prevalent in the waters of the Medway, especially Sheerness, and to a lesser degree at Portsmouth. [2] Later in 1780 the wood sheathing was removed and replaced with copper sheets conforming with the new legislation ordered by the Admiralty. This work comprised fitting 3,923 sheets of copper, [3] each measuring 4 feet (1.22 m) long and 14 inches (35.56 cm) wide. The hull area covered is estimated as about 14,711 square feet. In weight each sheet varied between 28 and 32 oz. (0.79 and 0.91 kg) per square foot, the heavier plates being fitted in areas more prone to water turbulance. This amounted to a weight of 17 tons (17.272 tonne). Each sheet was fastened with approximately 80 copper nails, [4] each being about 0.16 oz (4.5 g) in weight.* In total 313,840 nails weighing some 1.42 tons (1.44 tonne) were used. Some 20 reams of brown paper were used to line the hull before the copper sheathing was applied. From 1780 until 1888 work related to *Victory's* copper sheathing amounted to 15 occasions. For details refer to Appendix II.

When the actual extant plates were examined on site, it was revealed that the number of nails used exceeded 80. It was found that the average plate had about 43 nails along the edges of each long side and 12 on each short side. Further to this there were three rows of nails driven into the plates across the surface, each row comprising 11 in number. From this the average total of nails used per plate was 143, a figure that exceeds the original sum by some 63 nails. Obviously this figure would increase the overall weight of copper employed. Though the overall weight of copper sheathing and nails was substantiial, i.e. 18.42 tons (18.712 tonne), by comparison to wood sheathing, coppering would be considerably lighter. This salient point is a contributory factor to why speed was improved irrespective that marine growth was deterred.

The concept of using metal to protect ship's hulls was not new for it is known that the Romans often sheathed their vessels with lead fastened with copper nails. [5] This is further supported from archaeological evidence gleaned from the Roman Punic Ship. [6] There is no concrete evidence of sheathing after this period until 1514 AD when it appears that the Spanish were using lead for some of their ships. With respect to England the only reference relates to the those ships fitting out for Sir Hugh Willoughby's expedition to seek a NW passage to China in 1553. [7]

Apparently little experimentation was undertaken afterwards until 1671 when it was decided to furnish the 5th rate *Phoenix* (42) with lead sheathing held with copper nails. Sheathing of this nature was in fact fitted to 20 ships built between 1671 and 1690. To facilitate this an Act of Parliament was passed in 1670 granting exclusive rights for a 25 year period to Sir Philip Howard and Francis Watson for manufacturing milled lead. [8] Their first patent No.154, lodged 8 October 1667 permitted them rights for 14 years. Further patents were submitted, the last No.254 dated 13 August 1687, comprised, "*a new manufacture, art, or invention, by certaine engine or roller to draw, roll, or mill plates or sheets of lead by them cast or prepared for that purpose.........as well for sheathings shipps as for any other use or purpose whatsoever*" [9] It appears that lead was not overly successful inasmuch that it was too heavy and that it "*was not hard* *enough to endure long the action of the water".* [10] This point is further confirmed as result of trials carried out later in 1768. Moreover, galvanic action induced by lead incurred corrosion of iron nails and rudder fittings, as result the old Tudor method of sheathing in wood was reverted to. This itself had its drawbacks; though it deterred worm to a degree, it produced considerable drag to the ship. Second, hull defects were difficult to detect. [11]

On 2 October 1708 a letter was sent to the Navy Board from the Secretary of the Admiralty supporting a petition from Charles Perry concerning copper sheathing stating that, "*...your petitioners have, with great industry and charge, invented a new method of sheathing ships with British copper, which without hindrance to their sailing will preserve them from worms and barnacles in voyages to the East and West Indies, and prevent all occasion of careening and repairing them, which the common sheathing frequently requires."* [12] Unfortunately this suggestion was refused by the Navy Board on grounds of the expense. With regards to ships no other proposals were made however the idea of using copper was not completely dismissed. In 1717 Sir Isaac Townsend, the Commissioner of Portsmouth Dockyard, writing to the Navy Board suggested using copper to protect dock gates:

Portsmouth, 14th July 1717

.....PS. The enclosed is a proposal from the Master Builder and his Assistant for lining the gates of the great basin with copper, to prevent their being damaged by the worms, which (it has been observed) were the ruin of the former; and as it seems to me to carry with it a manifest advantage to the service more than sufficient to compensate the charge thereof, I humbly join in opinion with them and pray leave to submit it to your consideration. [13]

Resorting to accepted practices wooden sheathing remained the predominant method of hull protection for the next half century. The obvious problems prevailed; not only did this method fail to deter ship worm it also failed to eradicate encrustation of marine growth, the build up of which greatly impaired a ship's speed. Various actions were taken to combat this dilemma: A standard procedure for sheathing ships was authorised by the Navy Board 24 January 1727/8 which stipulated the following specification;

...to cover the bottom with thick brown paper and for preserving of the sheathing from the worm to fill with filling brads or nails, first taking care that all the iron work be carefully examined and secured, and the seams and butts of the bottom well horsed up and caulked and paid with common-tempered stuff as usual, and the bottoms all over with a good coat of soft-tempered stuff: the seams and butts listed with spun hair, and on that to cover the bottom with strong cap bag paper made out of old cordage and not of the sort made of woollen rags, each sheet, open, to be 22 inches by 1.1/2 inches , and each ream to weigh at least 45 pounds, scarped an inch over each other and tacked in each corner: then taking care that the sheathing board is sawed to a thickness, fayed, regularly edged, and to have two rows of holes bored in each butt to prevent splitting, and well dried with fire and paid thick with boiling tar, and that covered with hair well beat laid very smooth, and a good quantity of tar and hair: and then fastened to the side with sheathing nails about two and half inches asunder, and when the sheathing is caulked, to take down edges and butts as smooth as possible, and then fill it with filling brads or nails 1.1/4 inch long or so, as not to be more than half an inch in the plank, the heads to be about 3/8 of inch asunder, taking care the nails and brads are regularly drove and well soaked up that so the bottom may be as smooth as the nature of the work will admit, and then be well breamed and graved. [14]

As seen the procedure for sheathing in timber was a relatively complex affair. Graving compounds were then 'payed' over the entire surfaces to discourage weed and barnacles. Most compositions used were only successful in the short term. Some 10 patents relating to graving compounds were submitted between 1667 and 1779. [15] Whether all were actually applied is speculative. One such proposal, submitted by the 10th Earl of Dundonald, was the use of coal tar which did, after trials, appear suitable. [16] The best compound found was that introduced by Mr. Lee, the Master Caulker at Portsmouth in 1737. Lee's mixture comprised pitch, tar and brimstone. Trials lasting two years proved that worm had not penetrated. [17] When the *Victory* was first built she would have been sheathed in a similar fashion to that stated above, however as to which graving compounds were used, remains unknown. Perhaps traces may still be found on the old timbers which could be analysed.

Experiments, using copper on the keel, false keels, rudder bearding and sternpost were undertaken in the late 1750s on the *Norfolk, Panther* and *Medway.* [18] This appears to have been instigated by the fact that the *Invincible*, captured from the French in 1747, had her keel studded with copper nails.

On 18 October 1761 the Admiralty, under recommendation, authorised the Navy Board to sheath the *Alarm* frigate (32) with copper. This work was, according to the *Scots Magazine* of 1761, completed by the 9th November. [19] Next, the *Dolphin* frigate was similarly furnished for her voyage of exploration in 1764. Sheathing used comprised a layer of brown paper covered with copper plates of 12 oz. per the square foot. Each were to overlap 3/4 inch (1.9 cm). Plating commenced 1 foot (30.5 cm) below the waterline above which were placed elm boards 3 inches (7.62 cm) thick. [20] As with lead sheathing, copper sheathing produced its own inherent problems: Ships were still being constructed with iron nails, rudder pintles and gudgeons, all of which were found to corrode through electrolysis set up by dissimilar metals and sea water. In short this was serious, thus, to combat galvanic erosion, further experiments were made. In 1769 the *Aurora* and *Stag* were first breamed, then all the ends of iron bolts were paid with '*soft stuff*' (tar and pitch) then covered with canvas and very thin sheet, and rudder fittings were covered with lead. [21] Irrespective that the problem was not fully eradicated, the concept proved beneficial as shown from Admiral Keppel's letter 8 September 1778 concerning his frigates;

Victory at Sea.

I hope when the other two next dock that your Lordships will try the experiment of coppering their bottoms. If action is likely to be provided, I do think the expense upon calculation is not too great that at least ten of your 74 gun ships should be coppered. [22]

The concern to sheath ships with copper became paramount. Like Keppel, Admiral Rodney himself wrote, '*to bring the enemy to action, copper-bottomed ships are absolutely neccesary. Without them we should not have taken one Spanish Ship.*' [23]

Irrespective of cost, and the galvanic problem caused by iron fittings, the Comptroller for the Navy, Sir Charles Middleton endorsed a policy to sheath ships accordingly. This decision had the full support of both the King and the Admiralty. [24] As previously stated Victory was sheathed in copper in March 1780. At this period all bolts etc. fitted in the lower hull were still of ferrous material, thus she would have suffered the same galvanic problems aforesaid. This is highlighted in Captain Ferguson's letter to his brother, 1st March 1783; [25]

Some time ago I stepped into a dry dock, Where a Ship was under repair, which had been Copper'd, and observed the whole Bolts and Iron Work in the Bottom, between 4 and 5 Inches from the outside corroded and nothing but rusty dust, and having mentioned this in different Companies, I found myself laughed at. <u>But on the Victory being lately carried into Dock, it is found, That all the Bolts for 4 to 5 Inches inwards from the Copper, is sound and all the rest inwards to the Hold, nothing but rust and it is the general opinion of the Officers and Carpenters, who have inspected her, that had she touched the Ground ever so slightly she must have gone to pieces.</u> And on further Inquiry, I find the whole Ships which have been Copper'd to two years are in the same condition, and even My Old Ship Venus, which I got Copper'd in Antigua, and as I attended closely myself to this Operation.

I shall relate the Steps, I caused take to prevent the Copper from eating or corroding the Iron. After the Sheathing was riped (sic) off, 1. A strong Fire was put under her, all the Pitch burnt entire, and every little Nail taken out. 2. Two Strong Coats of White Lead and Oil put on. 3. Over the head of every Bolt, a Strong Coat of Pitch with Oakum and brown Paper. 4. Over that Canvas and a Plate of Lead drove on with Copper Nails. 5 Then the Copper Plates put over all & nailed down with Copper Nails about two Inches long. And it seems now to be the general opinion of all the officers I have met with, That our great losses by Ships foundering at |Sea, have been occasioned, by the Iron Work giving way as they were all Coppered.

The manner I see our Ships Coppered in our Yards at home is 1st. A Strong Fire to burn off all the Stuff from off the Bottom. 2. A thick Coal (coat ?) of Gluey Pitch. 3d. A

Strong Covering of pasteboard. 4. Then the Sheets of Copper put on. As this is the Subject of much Conversation How the Bolts, for 4 to 5 Inches next the Copper are sound, and all the rest nothing but dross I beg my Compl^{ts} to my Worthy friend Doctor Black, state the Case and let me know what he takes to be the cause of this.

I am told, that in the place of Iron Work, a mix'd kind of Brassy Metal is to be used for Bolts &c. But I greatly suspect it will be brittle, and want answer, for it is out of the power of man to build Ships so strong but by a heavy gale, they will twist and become elastic……… I am &^{c}.

The description given in the above letter verifies the method used to counteract the corrosion of iron carried out on *Aurora* in 1769. The fact that the *Victory* could '*have gone to pieces'* is particularly disturbing especially with regard to the tragic loss of the *Royal George* in August 1782. The perception of some people at the time was that the loss of the *Royal George* was due to structural failure, indeed one witness at the inquiry into the loss testified to hearing a load report of cracking timbers from below decks. Although the official result of the inquiry was that the *Royal George* was lost through a series of human errors relating to her being heeled to effect repairs, while simultaneously being loaded with stores on the opposite side of the ship, it cannot be ruled out that the failure of corroded iron hull bolts contributed to the loss of the ship. Should this have been the case, together with the later condition found in the *Victory*, then the fact that the rest of the coppered ships within the fleet were at sea in the same condition must have raised considerable concern for the Admiralty. Further research regarding ships losses for this period could be revealing.

Dr. Black's reply to Ferguson's letter raises some very interesting theories on the causes of corrosion. He also infers that the timber itself assists the corrosive process of iron. This fact is quite valid inasmuch that it is quite common for the oak surrounding an iron bolt to decay, due to the tannic acids inherent within oak reacting with the iron. The first indication of this problem is that the surrounding wood begins to turn black, it then breaks down and the iron bolt, by now already corroding, works loose.

Dear Sir,

I rec.^{d} from your Brother a Copy of that part of your letter of the 1^{st} Inst^{t} in which you relate your observations on the state of the Iron Bolts in the Bottoms of several Men of War which have lately been inspected……… being a point of the greatest importance to the British Navy. In all the Ships lately examined it appears that the greater part of the Bolts from the inner end of them to within 4 to 5 inches of the outside were completely decayed and changed into rust. & you suspect that the Coppering may have been the occasion of this…… one of your Officers, Mr. Yeats & he suggested a supposition that in rough weather at Sea the Bolts may be so much fatigued by the working of the ship that water may find room to pass along the surface of the Bolt from the outside inwards & that the water penetrates in this way receive from the Copper a disposition to corrode the Iron in its passage along it, but I cannot admit this supposition upon any account, it being evident that if the water passed in this manner & received from the Copper a Disposition to corrode the Iron, it w^{d} act most powerfully upon the first part of y^{e} Iron which it touched or passed along which would be the outer end of the Bolt……… let us suppose that there are originally in the Timber juices or some other matter which undergoes a change or Fermentation by time & gradually evaporates or is washed out in ships that are not Coppered, but that in coppered ships is confined by the copper & in consequence acts upon the Iron and destroys it ………… According to it this corrosive matter of the Timber should be most powerful toward the outside to which the Copper is immediately applied & should have little or no effect towards the inner end of the Bolt, where there is nothing to prevent its evaporating or being washed out in Coppered Ships as in others.

What then will you say, could be the occasion of the rotten state of the Bolts. The Suppositions that appear to me………… but they are merely Suppositions are these - 1^{st} -One Consequence of the Coppering is that the Ships require careening & inspection of their Bottoms less frequently than formerly as their bottoms remain clean & fit for sailing - but it may have been forgot that the Bolts are liable to decay & they may have been allowed to remain long without being renewed - 2^{dly} - All the world knows that we have been under necessity of fitting out our men of War with the greatest possible dispatch during the greater part of the War, I can imagine that in some cases when

Coppered Ships were docked, upon examining their bottoms the outer end of the Bolts being found good and sound which formerly was the first thought that decayed it was concluded that the whole Bolt was sound & it was therefore allowed to remain although the inner end of it without being suspected was totally changed into rust - 3^{dly} - Perhaps the Iron which had been used in the Navy for some time past may have been of a different quality from that which was used formerly, & more liable to Rust.........

You mention your having heard of an Intention or proposal to substitute Brass Bolts in place of Iron ones but you suspect that Brass will not be sufficiently tough and strong to serve this Purpose - I am persuaded however that a proper Composition of Brass may be found which will be as strong & even stronger than Iron & which will last incomparably longer....... [26]

It is interesting that Dr. Black, who was the Professor of Chemistry at Edinburgh University, states that the problem may have occurred because ships were being hurriedly sheathed without care to inspect underwater bolts beforehand. This could imply that Dockyard practices were either less stringent than believed; or more likely, that pressure of war to return ships to sea led to an oversight. It could also mean that Dockyards had not yet fully understood the implications of the process. It also raises the point that the standard of iron produced varied according to supplier and that there was no true quality control of material, albeit nothing comparable to the standards laid down today.

So grave was the corrosion problem that the Navy Board contemplated discontinuing the practice of coppering ships. [27] Fortunately a decision was made to substitute iron bolts and other fittings on all ships below the waterline with an alternative alloy. This policy was given considerable support from Thomas Williams, the prime industrialist behind the copper industry who, at the close of the American War, addressed the Parliamentary Committee;

'...a considerable alarm was given both in this country and in France from the loss of the famous French ships Ville de Paris *and the* Glorieaux [sic] *and His Majesty's ship the* Centaur, *together with many vessels at the same time, all which losses were concluded to be occasioned by the ships being copper-sheathed upon iron bolts and other iron fastenings; such was the general shock upon this occasion, I believe both our Admiralty and Navy Boards, on consultations in the latter end of the year 1782, meant to discontinue the practice of copper-sheathing, however useful it had been found for a time, on account of the great number of lives that have been lost, and the dangers that would afterwards attend it, unless copperbolts could be made sufficiently hard for the necessary drifts of those fastenings; all the copper bolts that had been made use of to that time having been very short ones, that required no tight drifts; and it was supposed that the metal was not capable of being wrought to the hardness necessary.* [28] It is of particular note that no mention is made to the sinking of the Royal George.

This option of replacing all iron fittings below the waterline was to be very expensive, however irrespective of cost Sandwich, the First Lord of the Admiralty, who more than anyone had pressed for sheathing ships with copper, consented to this action. Estimates for ships such as the *Victory* were approximately £2,272. [29] This figure equates to approximately 12 shillings per plate. Corroboration between the Progress Book and Ferguson's letter 1st March 1783; "*being lately carried into Dock*", clearly indicate that this work was executed in February 1783. (Refer Appendix II).

Various experiments were being made at this period to produce a tough substitute alloy to replace iron bolts and fittings one such was submitted by the industrialist and chemist James Keir in 1779, (Patent No. 1240). This comprised "*a compound metal capable of being forged when hot or when cold, more fit for the making of bolts, nails, and sheathing for ships than any metals heretofore used for those purposes, ...this compound metal consists of one hundred parts of copper, seventy five parts of zinc and spelter and ten parts of iron. When those proportions are mixed together, they constitute a compound metal, which may be forged either when cold or when heated to blood red*" [30]

Keir's compound metal appears to be the origin of the alloy Cunifer 10 used today for sea water system pipework. This modern alloy comprises 87% Copper, 10% Nickel, 2% Iron and 1% Manganese. The 'spelter' referred to would consist of approximately 59 - 61% Copper, 0.8 - 1.2% Tin, and 39 - 41% Zink, and was in effect what was termed as Muntz metal. The fact that this metal could be used for sheathing as well as bolts, etc. is of particular note.

A second patent, (No.1381), was lodged by William Forbes of Deptford 29 July 1783. Accordingly this related to; *"A method of manufacturing bolts and other fastenings for ships in a manner and of materials never hitherto made use for those purposes".* The bolts were made of, *"copper and spelter, zinck or lapis calaminaris in a proportion of from one pound to sixty of spelter zinck or lapis calaminaris to on hundred pounds of copper".* [31] Forbes' method of producing bolts involved cold rolling through a series of graduated grooves to aquire the determined diameter. If made in pure copper Forbes admitted that they were to some degree softer than those made in an alloy. [32]

Another patent (No.1388), submitted by William Collins in October the same year relates to iron bolts which were, *"plated with sheet copper or metal which is fixed to the iron either with brass or spelter, tin, or lead, alone, or with mixtures of them."* [33] The most significant factor is that industry was, by this period, prepared to experiment in metalurgy. This not only applied to the production of non-ferrous alloys, but also combinations of ferrous and non-ferrous materials. Besides this Collins, together with John Westwood, produced pure copper bolts of considerable strength. In Westwoods method after the copper was annealed it passed through adjustable rollers and continuously cooled with of jets of water to prevent it heating. [34.]

Accepting the problems found with electrolysis and the advance in producing compound materials the Admiralty finally authorised the use of the new patent bolts in 1784. These were to be fitted on all new ships under construction and to replace iron bolts on the older vessels as the opportunity arose. It appears that Forbes alone, through the support of Vice Admiral John Byron, attained an exclusive contract with the Royal Navy, and afterwards the East India Company. [35] Besides bolts and copper nails, Forbes also manufactured mixed metal rudder pintles and gudgeons, moulds being sent from each dockyard to Deptford. Initially this did create some problems as those taking moulds off the actual ships often failed to account for metal shrinkage in the casting process resulting in the returned items not fitting properly. This was overcome in due course. 1n 1793 a kinsman, one David Forbes is listed as a contractor suppling braziers and founders goods. [36] Three years later another supplier, John Williams, is listed as providing copper sheets, mixed metal nails, copper nails, bolts and rings. [37] Demand for copper increased as the fleet expanded. In 1803 a furnace was installed at Portsmouth Dockyard for melting old copper sheathing but it was to be another two years before a second furnace was introduced to accommodate refining and rolling machinery to produce new copper sheathing plates. [38]

It could thus be concluded that copper plates fitted during the *Victory's* career would have been supplied from a variety of contractual sources. To determine this point, albeit limited, an inspection of the plates removed from the *Victory* was undertaken in 1996 by myself, with assistance from John Bingemen and Arthur Mack, both of whom were previously connected with the *Invincible* wreck project.

With the exception of a few pieces adjacent to the keel and on the rudder, all copper plates fitted on the *Victory* in 1888 have subsequently been removed during recent restoration and placed in storage. On examination many pertinent points were revealed. Each was found to measure 4 feet (1.22 m) long by 14 inches (35.56 cm) wide and approximately 1/64 inch (0.38mm) thick. Others had obviously been cut or trimmed to suit a particular surface. Further analysis indicated that all plates were stamped with the government 'broad arrow' set at intervals of 4 inches (10.16 cm) in the horizontal plane and 2.1/2 inches (6.35 cm) in the opposite plane and thus formed a diagonal pattern across the sheet. The 'arrows' themselves measure 1/2 an inch (1.27 cm) long and 1/2 an inch (1.27 cm) broad **(Fig. 3/2)**. Plates were also stamped in one corner with a date enclosed within a circle 7/8 inches (223 mm) in diameter. In this particular case it read 'OCT 1888', **(Fig. 3/3.c)** a date which coincided exactly with the last time *Victory* was coppered. More enlightening is that these particular copper plates were also embossed with the contractors Trade Mark and weight of the plate within an oval shaped enclosure measuring 1.1/8 by 7/8 inches (28 by 223mm) containing the manufacturer name, 'JOHN BIBBY SONS & CO'. The innermost oval, which measured 3/4 by 3/8 inch (190.5 by

95.25mm), was marked with the weight of the plate, '28OZ' **(Fig.3/3.a & d)**. These plates were secured with copper nails 7/8 inch (223mm) long with a flat head 5/16 inch (79.4mm) in diameter. The round shank of the nail was found to be 1/8 inch (31.75mm) thick. On the particular plate chosen for inspection it was found that these nails were set at intervals of 1.1/4 inches (317.5mm) from their centres around the edges of the plate.

Though having identical date stamps, other plates indicated that they had been made by alternative manufacturers. Names found were 'Clifford', **(Fig. 3/3.b)** and 'WF & Co', both being preceded by a weight mark of 28 ozs as previously described. In all probability the initials 'WF' relate to the aforementioned known contractor William Forbes of Deptford [39] who previously manufactured 'mixed metal' (cupro-zinc) fittings such as gudgeons and pintles during the 1780s. Whether the company of Forbes was still in business a century later is yet to be clarified. Moreover it could be questioned whether the sheathing plates concerned were originals supplied from Forbes taken out of storage and used a century later, or more to the point, earlier plates that had never been removed.

Returning to the remaining copper still attached to the rother, or rudder, this apparently illustrates the later method of sheathing adopted from the Mercantile fleet into the Navy during the 19th century where the upper plates overlap the strakes of plates below. This method is the reverse to the initial practice sheathing first used in the Navy where the lower strakes overlap the upper plates. What little sheathing remains on the keel leaves little to formulate any sound opinion on the method used with exception that the copper plating sheathing the keel was fitted before the two false keels were fitted. With respect to the false keels, sheathing was applied after they were stapled to the main keel with copper alloy dogs. In perspective, the same should apply where the horseshoe plate was fitted at the forefoot, and the fish plates were attached to the heels of the stern post and inner posts. To the contrary, it appears from investigation that the copper sheathing was fitted before these heavy fastenings were bolted in position which, taking consideration of the logic process of construction and the function of these particular fittings, seems impractical. The reasons that lay behind this anomaly are for the present obscure. The only logical answer is that the horseshoe and fish plates have at some relatively recent stage been removed and refitted.

Whether the *Victory* shall ever be re-sheathed with copper plates is conjectural. Not only does cost prohibit such a undertaking, for practicality it seems hardly feasible to sheath a ship in dry dock. Should such a venture be deemed plausible then perhaps four of the uppermost strakes of copper could be fitted along with the appropriate elm boarding at the waterline. It has since been found that the practice of fitting elm boards at the waterline had been discontinued prior to c.1802, and the copper plating extended 16 inches above the waterline. As for other preserved ships, the *Unicorn* frigate at Dundee and the tea clipper *Cutty Sark* at Greenwich, both still retain their sheathing. With respect to the *Trincomalee*, currently being restored at Hartlepool, it is planned to sheath her hull in the near future. This action makes good preservation sense as both the *Trincomalee* and *Unicorn* frigates remain afloat.

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Fig: 3/1. The remains of Copper Plating at the after end of the Keel: HMS. Victory.

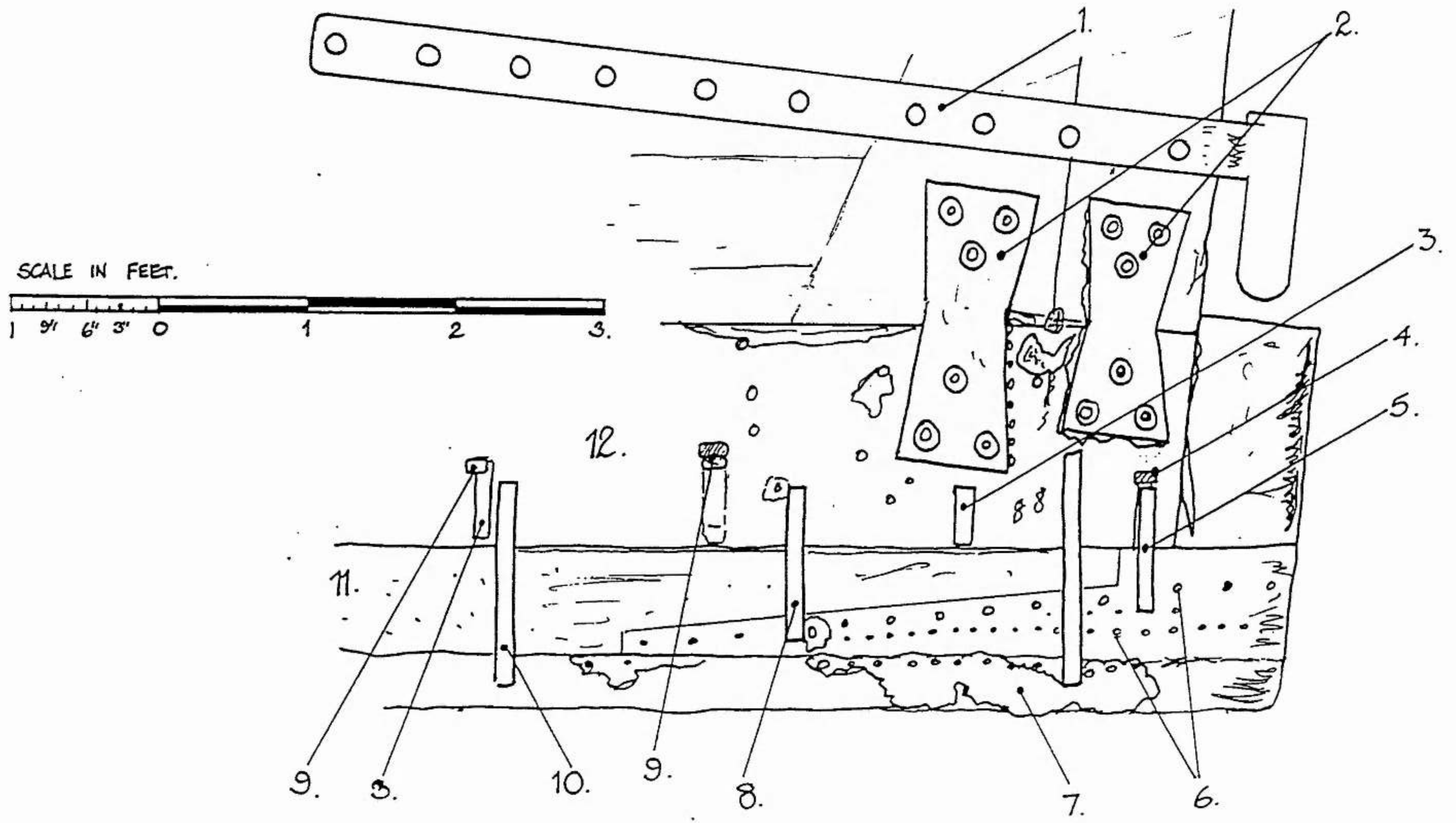


Figure 3/1.

Sketch of the remains of Copper Plating at the after end of the Keel: HMS Victory.

Key:

1. Lower Rudder Pintle Brace.
2. Fish Plates.
3. Redundant recess for old Keel Staple.
4. Remains of redundant Staple.
5. Short Staple joining 6 inch False Keel to Main Keel.
6. Copper nail heads.
7. Remains of Copper Sheathing on 4 inch False Keel.
8. Medium length Copper Staple.
9. Remains of two Staples.
10. Long Staple.
11. 6 inch False Keel
12. Main Keel.

Note: All Staples are 1.1/4 inches (32mm) by 1/2 inch (13 mm) thick.

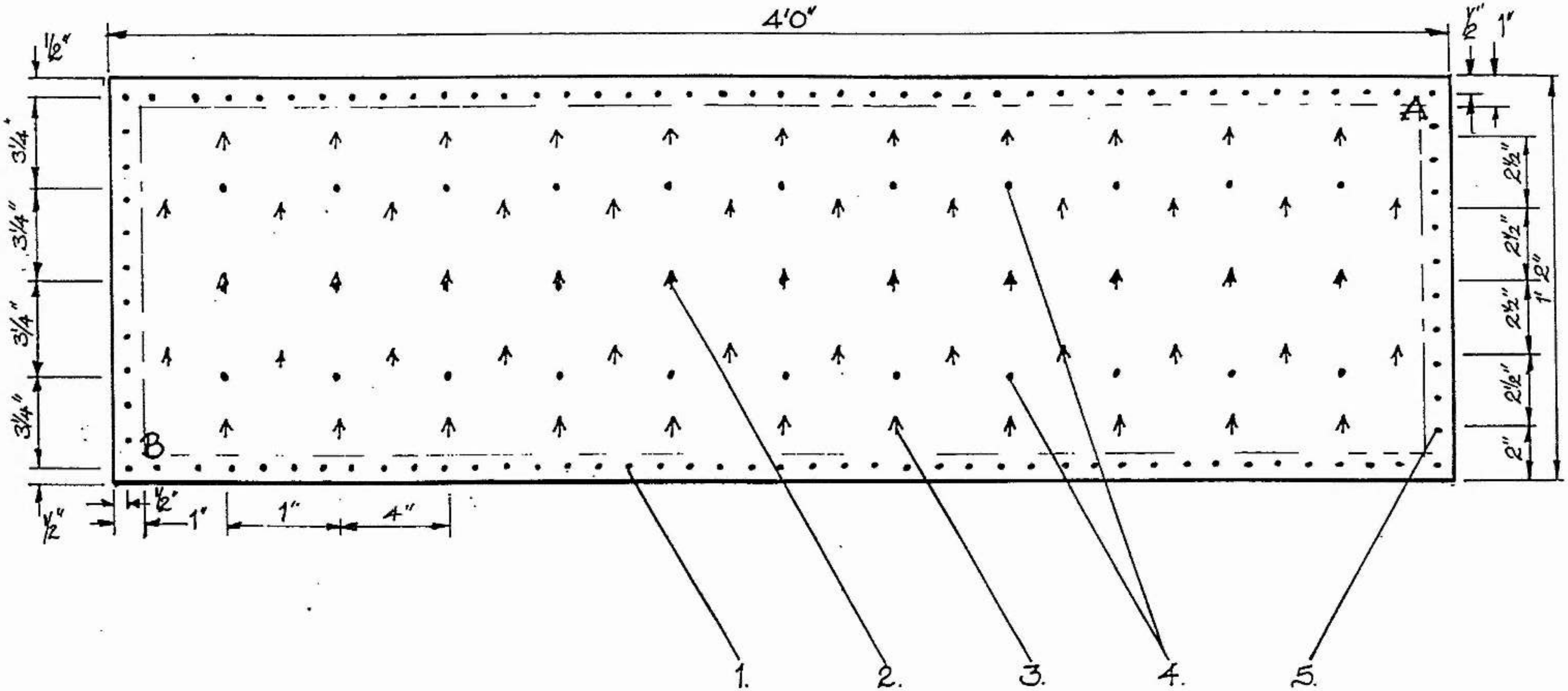


Fig. 3/2 : Copper Sheathing Plate removed from HMS. Victory. (scale 3/16"-1").

Fig: 3/2: Copper Sheathing Plate removed from HMS *Victory*. (scale 3/16" - 1")

Key:

1. Long edge run of nail holes - approx. 1.1/0 inches aprt
2. Centre row of 'broad arrows, also middle row of nails holes across plate.
3. Government mark of Broad Arrow.
4. Rows of nails holes across plate.
5. Short edge row of nail holes - aprox 1.1/12 inches apart.

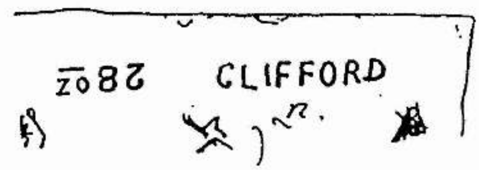
A This corner denotes location of manufacturers stamp.

B The reverse side of this corner denotes date stamp.

Note: Stamps for either manufacturer or date fitted do not always correspond with those corners indicated on the drawing.

Fig. 3/3 . Markings found on Copper Plates : HMS Victory.

a.



6.

c.

∂.

a. - Tracing of contractor stamp; John Bibby Son & C°.
6. - Tracing of contractors stamp; Clifford.
c. - Rubbing of date stamp; OCT 1881.
∂ - Rubbing of John Bibby's stamp.

Chapter 4.
Stern Construction.

In accord with general shipbuilding practice, when first built the *Victory* was constructed with a square stern with open galleries. These galleries, provided for the pleasure of the Captain and Admiral, were fitted at the level of the quarter deck and the upper gun deck respectively.

The square stern as we know it derived from the early Tudor period, however its origins pre-date this era when medieval ships were first built with an after castle for defensive purposes. By the 13th century this elementary platform had developed into a permanent structure and by the 14th century had become built integral with the hull. [1] The recent built British replica of Cabot's *Matthew* (1497) is a prime example. Here the frame timbers extend higher to form the side of the cabin structure. As time progressed this structure became larger, extending aft beyond the confines of the stern post with enclosed cabins to accommodate the ship's officers. Additional decks were added thereby forming what became known as the quarter deck and the poop (L. puppis - aftermost deck). This effectively provided more space for the crew. The lower part of the hull remained of round tuck form with the wales carried round to the stern post, the structure above being supported on brackets. In short this design was structurally unsatisfactory. This problem was overcome by constructing the lower part of the stern with a flat transom. This modification, known as the square tuck developed sometime during the 15th century however the true origins of this design are little known. [2] The upper part of the stern projected aft in a series of counters.

Open stern and quarter galleries where next introduced possibly as early as circa 1480 [3] and remained in vogue. The square tuck remained throughout the Tudor period but began to disappear from English ships in the first quarter of the 16th century, [4] design returning to an improved form of round tuck. This appears first evident on the *Constant Reformation* 1618 and later the *Sovereign of the Seas* 1637. [5] The reversion to the round tuck was probably made for the following reasons;

1. More solid construction providing greater strength.
2. Less liable to leaks.
3. Better underwater hull form thereby improving steering capabilities.
4. More aesthetically pleasing.

An analysis of a number of contemporary models and draughts of the *Victory* when first built in 1765 show that she was initially constructed with two galleries. [6] This design, known as the open stern, was considerably simple comprising two side counter timbers forming the after extremity of the hull above the waterline. These extended from the upper edge of the wing transom to the taffrail above the level of the poop deck. Between these were six short counter timbers which terminated at the level of the upper gun deck beams. The timbers, which formed the divisions of the wardroom lights (stern windows) at the after end of the middle gun deck, provided the only solid structure of the stern. All of the counter timbers were braced with a series of transverse beams: The wing transom, helm port transom, respective deck transoms and a breast rail, the latter at the level of the wardroom. At this period, most, if not all, of these transverse timbers were secured to the ship's side using horizontal timber knees. Without the original draught the sizes of these knees can only be determined from alternative sources, [7] estimates being as follows;

Table 4/1.

Estimated Dimensions of respective Transom Knees: *Victory* as built 1765.

Transom Knee.	**Siding (ins.)**	**Arm Length; fore & aft**	**Arm Length; athwartships**	**No. of Bolts**	**Bolt Dia.**
Wing Transom	13.1/2	18 ft. 0 ins.	7 ft. 6 ins.	14	1.3/8 ins.
Helm Port Transom.	9.1/2.	11 ft. 6 ins.	6 ft. 4 ins.	14	1 inch.
LGDk. Deck Transom.	11	As convenient	5 ft. 0 ins	8	1.3/8 ins
Breast Rail	10	As convenient	4 ft. 6 ins	7	1.1/4 ins
UGDk.Deck Transom.	8	As convenient	4 ft. 3 ins	7	1.1/8 ins
QDk. Deck Transom.	Iron	-	-	-	-
Poop Deck Transom	Iron	-	-	-	-

Notes: Where 'as convenient' is stated, this refers to the length of the arm being that space given between the transom and its adjacent beam. Where 'Iron' is stated, this infers that iron brackets were used.

Outboard of the two aforesaid side counter timbers were two quarter pieces (or posts) which formed the extremities of the quarter galleries. Unlike the other counter timbers, the heels of the quarter pieces were not let into the wing transom but onto a stool bolted to the ship's side.

The two original stern galleries projected about 3 feet 6 inches (1.07 m) abaft of the hull line of the counter timbers. [8] Transversely both galleries extended in a graceful curve confined within the limits of the two side counter timbers. In effect the after end of both the upper gun deck and quarter deck were of open construction, closed only by transverse screen bulkheads fitted within the hull at the aftermost deck beam. The screen bulkhead fitted in the Admiral's quarters was fitted at original No. 26 quarter deck beam, while that for the Captain's cabin was fitted at the aftermost poop deck beam. The area formed abaft these bulkheads was provided to form open stern galleries which projected beyond the confines of the ship's hull. Screen bulkheads were, by this period, fitted; *"...with a single sash and shutter: that the height be so divided that the depth of the sash may be equal to the panel below, that both sash and shutter may be buried therein when down,"* [9] for easier removal when clearing the ship for battle. Practical though this seems, the main disadvantage was that any ship built in this manner was very susceptible to raking shot fired by the enemy through the stern penetrating the full extent of the hull causing irrevocable damage and high casualties. Such destruction can be gleaned from the result of the raking broadsides delivered through the stern of the French ship *Bucentaure* by the *Victory* and successive ships in line at the Battle of Trafalgar.

Access to each of the stern galleries was attained through two doors fitted in their related screen bulkheads. [10] By this period quarter galleries were entirely enclosed, access being attained through doors leading from their associated cabins, and, in all probability, a second entry could be made direct from doors leading from the stern galleries. [11] Unfortunately original draughts of the *Victory* do not indicate which door configuration was employed. Luckily alternative sources, draughts of the *Sandwich,* [12] *London,* [13] and *Boyne.* [14] do provide some indication;

***Sandwich*: 2nd Rate, 98 Guns, 1759:**

Quarter deck: 1 door leading from the stern gallery.

Upper gun deck: 2 doors; One leading from the great cabin, one from the stern gallery.

Middle gun deck: No door shown, however one would have been fitted in wardroom. Of note, this omission is, in all probability, is drawing error.

***London*: 2nd Rate, 90 Guns, 1766:**

Quarter deck: 1 door leading from the stern gallery.

Upper gun deck: 2 doors; One leading from the great cabin, one from the stern gallery.

Middle gun deck: 1 door leading from the wardroom.

***Boyne*: 2nd Rate, 98 Guns, 1790:**

Quarter deck: 1 door leading from the stern gallery.

Upper gun deck: 2 doors; One leading from the great cabin, one from the stern gallery.

Middle gun deck: 1 door leading from the wardroom.

It also appears that the *Victory,* like all 1st and 2nd Rates constructed during the 1760s and 70s, had four counter or chase ports cut in the lower counter, a trait that continued until the 1790s. This is evident from various model and drawing sources. [15] How often these ports were actually used for mounting stern chase guns is somewhat obscure. The entire concept of running guns out with a stern running sea is rather impractical especially as *Victory* carried heavy 42 pounders on board at this period. Second, there is very little space to successfully mount and operate four guns. In reality, if guns were mounted at this location, those outboard would have recoiled into the side of the carriages of the aftermost broadside guns. In truth, no additional ordnance was actually carried for the stern chase ports; if required, the aftermost broadside guns were removed and run out through the stern ports. Counter, or stern chase, ports were more commonly employed for running out cables when anchoring astern. Of note, the aforesaid model is furnished with window mullions at the out board ports which indicate that the main purpose of these ports were to provide light and ventilation to the gunroom.

Further study reveals that in order to fit four counter or chase ports, the disposition of the lower counter timbers would have differed from those later fitted during *Victory's* 1800/03 refit. Unfortunately, as original plans are now lost, the only reliable source that verifies this point is the contemporary model of the ship. [16] This model indicates that the line of the lower counter timbers do not correspond to the disposition of the wardroom stern lights. In fact the four chase ports fall directly below the lower counter timbers, a point that was common to other vessels. From this it is clear that the counter timbers comprised two groups; those of the lower counter forming the divisions between the chase ports; and those of the upper counter forming the divisions of the wardroom lights. Alternatively, depending on their position, some of these frames may have been made from canted timbers. [17] Should this have been the case timber selection, especially when accounting for the curvature of the counters, may have proved difficult.

Irrespective that *Victory's* elaborately decorated stern was graced with superb lines when first built, this form of stern was far from practical, and furthermore very weak structurally. Unfortunately ship design was very much rooted in conservative traditionalism. In 1795 *Victory's* commander, Captain Grey, reported; *"I have observed that the ship is very weak abaft; the transoms between the lower and middle-decks work exceedingly."* [18] This problem was not just confined to the *Victory* but inherent, in many ships. In 1797 it was reported that the tiller of the *Agamemnon* (64) ; *"traverses entirely on the helm-transom"* and that the *"stern-post works."* [19] Some ships actually worked the heels of their counter timbers out from the wing transoms in relatively normal sea conditions. The *Queen Charlotte* (100) was reported to have her; *"counter timbers being tript* (sic) *in the heel 1.1/4 inch."* [20] In all some 142 reports were submitted between 1795 and 1815 by sea officers serving on ships ranging from 1st to 6th rates, each ship suffering similar structural failures. [21] The consequences of design failure cannot be emphasised too strongly and may well have contributed to ship losses at sea.

The fact that all counter timbers did not extend the full height of the stern meant the rigidity of the hull form abaft was greatly compromised; lack of structural timbers subjected the after part of the hull to considerable racking. Second, by virtue that stern galleries extended beyond the hull, structural timbers that were fitted had to bear the unnecessary weight incurred. To reiterate the more practical points, ships built with an open stern suffered much damage by raking fire. With respect to comfort, many sea officers complained that the screen bulkheads did little to deter draughts when ships were on constant blockade.

Initially little could be done to completely eradicate the problem as Britain was engrossed in war with France however some measures were taken to alleviate the situation. As an intermediary remedy, the first measures undertaken were to reduce the galleries back to the counter timbers and glaze the space above the breast rail. [22] This appears to have been implemented circa 1796. Complete reconstruction, where all the counter timbers were extended to the taffrail, was later carried out on the *Royal George* (ex *Umpire* - launched 16 Sept 1788) followed by the *Vanguard* in 1798. [23]

Initially the *Victory* would not have been modified with the closed stern. On her return from the Mediterranean she was surveyed at Portsmouth in October 1797 and found defective and after paying-off was sent to Chatham for conversion into a hospital ship and inevitable obscurity. Fortunately, with the loss of the *Impregnable* (98) off Chichester harbour, 18 October 1799, [24] the *Victory* was given a reprieve. The Admiralty, now short of one three decked ship, ordered that *Victory* be 'taken in hand' at Chatham. The first survey indicated that she needed a *'middling repair'* and consequently work commenced February 1800. As her refit progressed it was soon revealed that her condition was more serious thus the *'middling'* work promulgated reverted to a *'great repair'* during which she was reconstructed with a closed stern.

In light of the structural complaints submitted earlier by Captain Grey, work would have involved the removal of all stern counter timbers including the wing transom. When replaced the new timbers extended the full height to the taffrail, all transversely stiffened with breast rails as well as deck transoms. All timbers now formed stern lights for the cabins on the middle, upper and quarter decks. When rebuilt only two chase ports were fitted in the lower counter in preference for the previous four. This improvement was applied to all ships under reconstruction.. In effect the entire structure was far stronger. The taffrail had also been heightened by a small degree, probably to give greater protection for personnel stationed on the poop deck.

Another innovation implemented was the introduction of additional chase ports at each respective deck level. These ports were disposed one directly on the centre line and one between the second and third counter timbers either side. In effect this gave provision for nine guns: Three ports on the quarter deck, three ports on the upper gun deck , but only two on the middle gun deck; the latter being the exception as the rudder head protruded through this deck level. Access to these ports was made by;

1. Raising the deadlight.
2. Removal of the vertical panels covering the stern timbers to expose necessary ringbolts.
3. Removal of the back panel.
4. Removal of the bench seat.
5. Slipping the port lid bolts and pushing the lid downward. [25]

The *Victory's* overall fire power aft in 1805 comprised 11 guns: 2 x 32 pounders; 2 x 24 pounders; 3 x long 12 pounders; and 3 x short 12 pounders. As stated before, no additional armament was carried for chase guns, thus guns would have been taken from the broadside batteries if required. Irrespective of improvement, the scantlings of the stern counter timbers still remained proportionally smaller than those forming the frames of the ship's side. In view of their frailty it is doubtful if guns were ever mounted astern as the recoil affect would have been very detrimental to structural strength if firing was sustained over a moderate period. Of note, the original lower gun deck armament of the *Victory* consisted of 42 pounders, these were however changed for the more favourable 32 pounder after her 1800/03 refit. Although the 32 ponder was smaller and lighter in weight, advantageously guns of this calibre were far more manageable, and operationally, required less crew. They also used less gunpowder - a 10.1/2lb (23kg) charge as opposed to 14lb (30.9kg).

Today, all of the main timbers and framing of the stern remain original from *Victory's* 1800/03 refit. The only alterations made, prior to the extensive repair work carried out on the stern during the 1970s, are the fitting of additional iron bracing straps. Consensus is that these were fitted during her 'great repair' at Chatham, however it is unlikely that this was the case. Iron work, if fitted, was at this period only used in extreme cases and was not officially introduced until 1805. [26] (refer Chapter 7). For convenience ironwork currently fitted has been categorised into three distinct functional groups;

Group I: Comprises a series of iron straps worked and bolted over the heels of the counter timbers, helm port transom, wing transom, and filling transom. Though of plain design, each is fashioned with a cross piece which lays over the wing transom for additional security.

Group II: Relates to two large horizontal iron knees which secure the extremities of the wing transom to the spirketting. These knees are fashioned with ten lugs to give better material strength where bolting. These replaced the earlier heavier wooden knees, the size of which must have proved difficult to procure by the end of the 18th century.

Group III: These are of a series of iron brackets fitted at the extremities of the transoms and breast rails securing them to the ship's side. **(Fig. 4/1)** These brackets, some intricately fashioned and angled in three planes, are manufactured of relatively heavier gauge metal than those applied in Groups I and II.

Most of the ironwork seen today was probably fitted during *Victory's* rebuild in 1814/16, but this may not be the complete case. When exactly each type of iron fitting described above was installed in the *Victory* is uncertain, our only clue relates to their design. The only method of dating these components with some degree of accuracy is to compare them to other known examples of similar type whose design relates to a specific date. From this the approximate time of installation can be established. The ironwork as described in Group I is of simple design which could indicate an earlier manufacturing technique. However in view that *Victory's* stern was completely rebuilt in 1800/03 there was probably no initial requirement to strengthen this part of the ship. The earliest possible date of fitting would be her repair at Chatham in 1806. This refit not only restored action damage sustained at Trafalgar, her previous two years service on blockade duties and the 'great chase' across the Atlantic might well have weakened her hull to some degree. Alternatively they might have been fitted during her repair in 1810 after service in the Baltic.

Turning to Group II, the singular features of the iron knees fitted to the wing transom very much resemble those designed by Snodgrass in the 1780s (refer Chapter 7). This could indicate that these were actually fitted during the 1800/03 refit especially when compass timber of this scantling was in short supply. Irrespective of this theory, Steel indicates that timber knees were still being applied, their dimensions having little altered from that specified in 1788. [27] This is also applicable to the helm port transom. Again, if not fitted 1814/16 then they could also have been installed circa 1810 when ironwork was being applied to other ships [28] as result of its formal introduction in 1805.

With respect to Group III, ironwork to secure deck transoms on higher decks had been in use since circa 1788. [29] This naturally extended to the breast rails once the closed stern had been introduced. Though this point is valid, and that the *Victory* was so fitted in 1800/03, the ironwork presently fitted does not correspond to this period. Examination has indicated that these fittings, including the iron bracket knees supporting the aftermost deck beams, are similar to those introduced by Seppings. (refer Chapter 7). Identical ironwork of similar thickness is fitted on the frigate *Unicorn* (1824). This indicates that this design of ironwork, probably introduced circa 1820, could very well have replaced earlier iron brackets during *Victory's* refit in 1824. Any earlier date; i.e. 1814/16, is very unlikely as fittings of this nature (with the exception of two which were probably added in 1849) are not found on the *Trincomalee* built in 1817.

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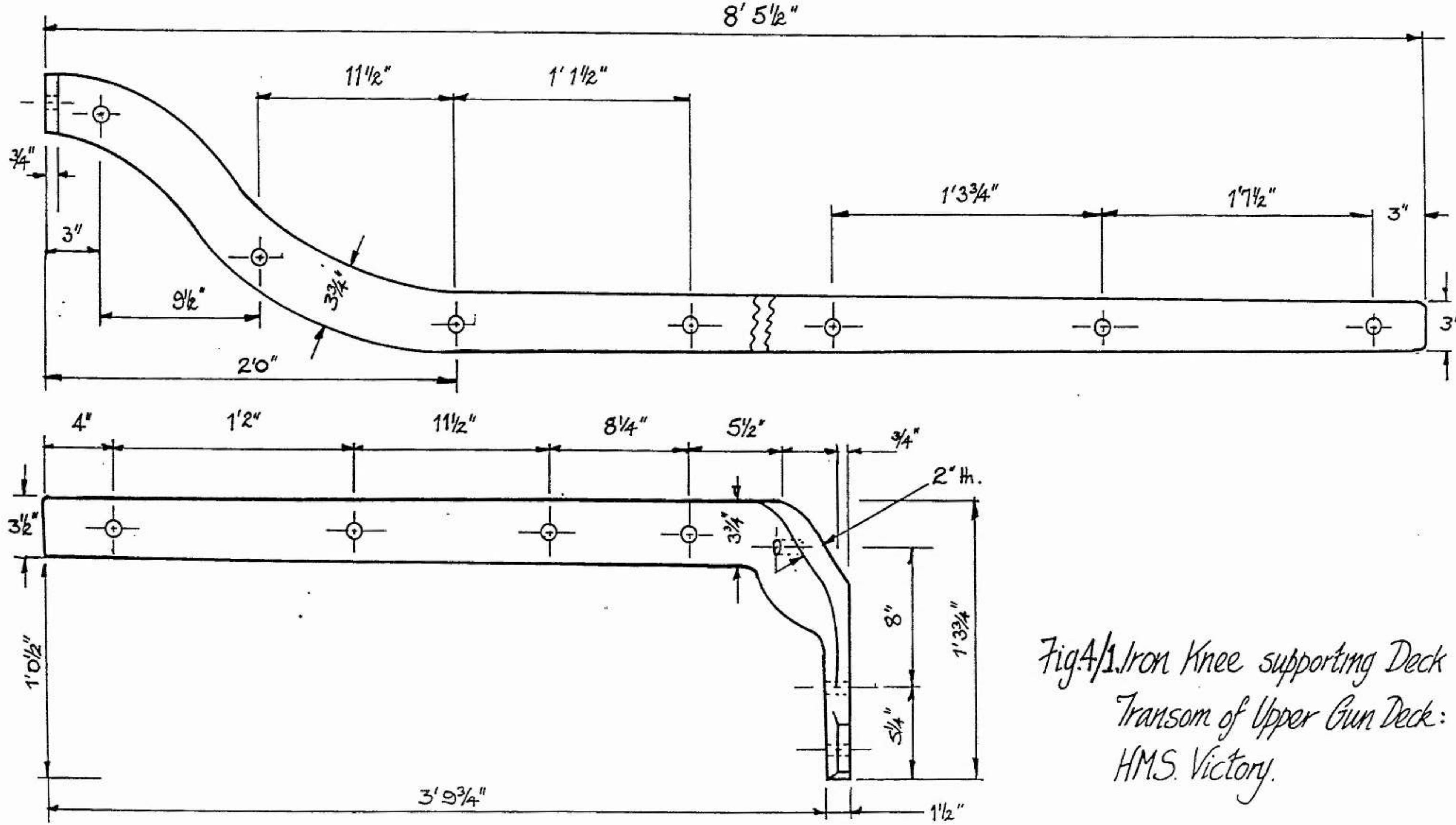

Fig.4/1. Iron Knee supporting Deck Transom of Upper Gun Deck: HMS. Victory.

Chapter 5.

Breadth, Middle and Top Riders.

In the second half of the 18th century it was common practice to brace the hull of older or fatigued ships to prolong their serviceable life. This practice was also implemented to maintain a high complement of ships within the fleet during periods of war. Moreover, it was often found that additional bracing was fitted to relatively new built vessels in order to make good deficiencies found with initial design. For example, the *Blandford,* one of the many 20 gun ships built to the 1719 Establishment, was later furnished with riders in the hold. In this particular case no specification for riders was listed within the Establishment, however the Master's Log for the *Blandford,* dated 25 May 1731, clearly states: "*Hauled ashore to the Wharf in order to drive and clench the Bolts of the Ryders on the Larboard side.*" [1] Such ships though would never have been braced with breadth, middle and top riders which were applicable to three decked ships. With respect to two-deckers only the breadth and top riders would have applied.

The two major stresses, hogging and sagging, imposed on a hull working at sea were well understood, even by the ancient Egyptians. The earliest known technique utilised to counteract such force can be found on reliefs found within the mortuary temple of King Sahure (2487-2475 BC). [2] These depict a crude but effective method employing a heavy rope, known as a *hogging truss,* passed from stem to stern that could be tightened by a 'Spanish windlass' device. Many examples are found in tombs from this period onwards. [3] According to Apollonius,[4] a similar device called a *hypozõma* was applied to the ancient Greek triremes. [5] In all probability the *hypozõma*, like many other things, was adopted from the Egyptians, but unlike the Egyptian *hogging truss,* the *hypozõma* was fitted low down within the hull running parallel to the keelson. [6]

Returning to the breadth, middle and top riders fitted on 18th century men-of-war, each was fitted to the inner side of the hull extending from the beam shelf of one deck to the bottom of the spirketting of the deck below. The middle and breadth riders gave shift of one deck to maintain continuity. In most cases all were set at a small angle varying between 10 and 20 degrees to the vertical to counteract stress forces, their disposition being dictated by beam, hanging and lodging knee configuration. A typical 74 gun ship would have 11 top riders and 12 breadth riders. [7] The direction of angle also varied according to the disposition of adjacent hull structures, some fitted angled forward, others aft, the former being more common but there were no hard and fast rules. In some cases riders were fitted vertically giving support to adjacent beams. [8]

When such riders were first used is now conjectural especially when original draughts pertaining to specific vessels were amended at some later date without explanatory annotation. One draught of the *London* (90), designed by Slade, does show that she was at some point fitted with 6 top, 3 middle, and 2 breadth riders either side. [9] Notes writtten on this draught which refer to same class ships, the *Impregnable* fitting at Deptford and *Prince of Wales* at Woolwich, are dated 1782 and 1783 respectively. Whether this relates to the riders fitted in the upper hull is obscure, only extensive research through the Navy Board and Dockyard letters could reveal some formal start date for fitting this form of rider. It is very unlikely that the *Victory* was ever fitted with riders of this form when first built however evidence provided from later plans implies that she was fitted out with 35 such strengthening members each side of the hull. [10] It is believed that these were added during her 1787 refit. **(Fig. 5/1)** This would make sense as this date complies with the two dates mentioned in the above paragraph. The disposition of Riders indicated on the aforesaid plan are as follows;

Top Riders - 12 in No.

No. from Fwd.	Frame Station	Angle	Inclination	Length	Breadth
1	U	7.5°	Aft	12 ft. 6 ins.	1 ft. 2 ins
2	Q	23.0°	Aft	13 ft. 6 ins	1 ft. 1 in.
3	K	3.0°	Fwd	13 ft. 2 ins.	1 ft. 2 ins.
4	F	5.0°	Fwd	13 ft.	1 ft. 1 in.
5	D	25.0°	Aft	14 ft. 7 ins.	1 ft. 2 ins.
6	(F)	14.0°	Aft	13 ft. 6 ins.	1 ft. 1 in.
7	⊕	8.0°	Fwd	13 ft. 3 ins.	1 ft. 1 in.
8	7	20.0°	Aft	13 ft. 5 ins.	1 ft. 1 in.
9	15	10.0°	Aft	13 ft.	1 ft. 1 in.
10	21	20.0°	Fwd	13 ft. 4 ins.	1 ft. 1 in.
11	25	25.0°	Fwd	13 ft. 8 ins.	1 ft. 1 in.
12	27	4.0°	Aft	12 ft. 10 ins.	1 ft. 1 in.

Middle Riders - 11 in No.

No. from Fwd.	Frame Station	Angle	Inclination	Length	Breadth
1 *	Z	17.0°	Aft	20 ft. 9 ins	1 ft. 2 ins
2	O	25.0°	Aft	14 ft.	1 ft. 1 in.
3	K	22.0°	Aft	13 ft. 9 ins.	1 ft. 1 ins.
4	F	24.0°	Aft	14 ft.	1 ft. 2 in.
5	B	7.0°	Aft	12 ft. 11 ins.	1 ft.
6	(D)	11.0°	Aft	12 ft. 11 ins.	1 ft. 1 in.
7	5	11.0°	Aft	12 ft. 11 ins.	1 ft.
8	11	12.0°	Fwd	13 ft.	1 ft. 2 in.
9	19	14.0°	Fwd	13 ft. 4 ins.	1 ft. 1 in.
10	23	14.0°	Fwd	13 ft. 2 ins.	1 ft. 1 in.
11	29	27.0°	Aft	14 ft. 9 ins.	1 ft. 1 in.

Note: The foremost middle rider, denoted * extends from the beam shelf of the forecastle to the lower part of the lower gun deck spirketting.

Breadth Riders - 12 in No.

No. from Fwd.	Frame Station	Angle	Inclination	Length	Breadth
1	Z	1.0°	Aft	12 ft. 10 ins	1 ft. 2 ins
2	S	12.0°	Fwd	13 ft. 2 ins.	1 ft. 2 in.
3 **	P	11.0°	Aft	17 ft. 2 ins.	1 ft. 2 ins.
4	H	0.0°	Vertical	13 ft.	1 ft. 1 in.
5 **	D	10.0°	Aft	17 ft. 2 ins.	1 ft. 2 ins.
6	(F)	0.0°	Vertical	12 ft. 10 ins.	1 ft. 1 in.
7 ***	(B)	0.0°	Vertical	12 ft. 9 ins.	1 ft. 1 in.
8	3	2.0°	Fwd	20 ft.	1 ft. 1 in.
9 **	7	0.0°	Vertical	17 ft.	1 ft. 1 in.
10 **	12	0.0°	Vertical	17 ft.	1 ft. 2 in.
11	23	11.0°	Fwd	12 ft. 9 ins.	1 ft. 1 in.
12 **	29	13.0°	Fwd	17 ft. 7 ins.	1 ft. 2 in.

Notes: Those denoted such ** are of greater length and extend below the level of the orlop deck. That denoted such *** extends upward to the beam shelf of the upper gun deck, and downward to the level of the orlop deck.

From the above notes, it appears that the design of some of the riders fitted deviates from the normal accepted practices where riders extended over two decks only. The anomalies relate to No. 1 middle rider and No. 7 breadth rider which each span three decks. Second, it is of particular interest that five of the breadth riders are set in the vertical plane. Though length and breadth sizes can be determined from the draught, the moulded breadth of the riders fitted on *Victory* cannot be fully acsertained from firm evidence. Dimensions by rule of thumb are; moulded breadth (athwartships) is 1.1/4 inches for every 1 foot in length (4.233 cm per meter); breadth fore and aft, 3/4 of the moulded breadth. [11] From the above tables the breadth fore and aft average 1 foot 2 inches (35.56 cm) thus moulded breadth can be equated as approximately 1 foot 6.1/2 inches (47.0 cm).**(Fig. 5/2)** From the draught its appears very unlikely that the scantling fore and aft was increased to give support to adjacent beams. This practice seems to emerge at a latter date when it was realised that considerable timber could be saved by disposing the Riders in such a manner that they served both as a hanging knee and rider combined·[12] .

Further evidence that breadth, and presumably middle and top riders, were added to the *Victory's* structure is clearly indicated within the painting *The Death of Nelson* by Arthur Devis in 1806. **(Fig. 5/3)** In this painting Nelson is seen laid against what appears to be top of a Futtock Rider which terminates directly below a gun-deck beam. (this structure has apparently been altered since). Further to the right of the painting a second gun-deck beam is shown supported with a wooden hanging knee: Between this knee and where Nelson lay is another vertically wrought baulk of timber which disappears behind a carling at the deckhead. **(Fig. 5/4)** *By its sheer size and disposition this can only be the lower part of a Breadth Rider.* [13] The position of this Breadth Rider depicted within the painting complies very closely with the *Victory* profile draught dated c.1787 the title of which is annotated with the statement; '*with the Riders ticked in Red*'. [14] **(Fig.5/1)**

If the *Death of Nelson* painting by Devis is an accurate representation which complies with the disposition of the Riders as depicted in the draught c.1787 then the assumed place where Nelson actually lay and died could be questionable. To re-iterate, the rider shown in the painting, is virtually *set in the vertical plane and fitted abaft a hanging knee*. This fact, according to the draught, indicates that the nearest vertically wrought Riders were disposed either further forward or aft of the traditional location where

Nelson died. If fitted, vertical breadth riders were disposed adjacent to Nos. 14, 15, and 20 lower gun deck beams.(Stations, [B], 2 and 12). Relative to the orlop deck, these locations are; [B] a little abaft the cable tier; 2, abreast the main mast; and 12, inside the Captain's steward's cabin further aft . Ignoring the latter, which is quite impossible, the most probable rider is that disposed at station [B]. This theory is supported from further evidence given in the painting inasmuch that pillars forming the after boundary of the cable tier are clearly shown to the right hand side of the painting. On more practical grounds the events at the Battle of Trafalgar also have to be considered. The emergency action operating theatre was set up in the after cockpit. For convenience casualties sustained before Nelson was carried below would have been placed nearer to the operating table thus Nelson would have been laid further forward nearer the cable tier, space aft being already occupied. The fact that he could have been placed a little further aft at Station 2 is doubtful as the rider at this point, if conforming to the aforesaid 1787 draught [15] was the lower part of an extended middle rider which was not vertical but set at 2 degrees: The painting clearly indicates that the rider shown is vertically fayed to the adjacent hanging knee. Alternative paintings depicting Nelson's death do not, by virtue of their orientation, show this form of structural detail.

Another source of evidence indicating that riders were fitted comes from entries recorded in a 'Remark Book' held by Midshipman Roberts who was on board at Battle of Trafalgar, Roberts states;

'Defects to HMS Victory 5th December 1805. Thos. M Hardy Esq., Captain. The Hull is much damaged by shot in a number of different places, particularly in the wales, strings, and spurketing (sic), and some between wind and water. Several beams, knees, and riders shot through and broke; the starboard cathead shot away.........' [16]

In 1996, as Curator, I undertook a series of surveys on the old timber frames which were revealed when planking was being removed from the larboard side of the ship during current restoration. [17] The purpose of this inspection was to find physical evidence that riders had once been fitted. Unfortunately many of the timbers appeared to have been replaced and many of those timbers found that pre-dated Trafalgar 1805 were badly rotted through, so much so that the fabric virtually crumbled in the hand. The intention of the survey was to determine the location of any remaining bolts which may have secured the riders, whether they be later cut through or the holes plugged when the riders were removed. Unfortunately the survey, which has yet to be fully analysed, has not revealed any conclusive evidence. This point was expected as besides structural repairs executed at Chatham in 1806 after Trafalgar, considerable rebuilding work was also undertaken during the 1814-16 refit. When rebuilt all top, middle, and breadth riders would have been removed due to the implementation of fitting iron plate knees and beam end chocks. (See Chapter 7).

To conclude, top, middle and breadth riders were a practical, simple, and effective evolutionary step towards reducing the inherent hogging and sagging problems common to al wooden warships. Furthermore, they served to brace a weakened hull system. Construction was simple as timber used was of the straight form more readily procured. In all probability most would have been made from sound timbers removed from ships taken apart or from surplus off-cuts. One salient point that is very clear is that their application, albeit practical and short term, greatly influenced the later technique introduced by Seppings where diagonal timbers were wrought between gun ports. The only surviving example of this type of construction can be found on the *Unicorn* frigate at Dundee. This unique ship encapsulates all the classic innovations of the Seppings System.

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rks of His Majesty's Ship Victory

Fig. 5/1.

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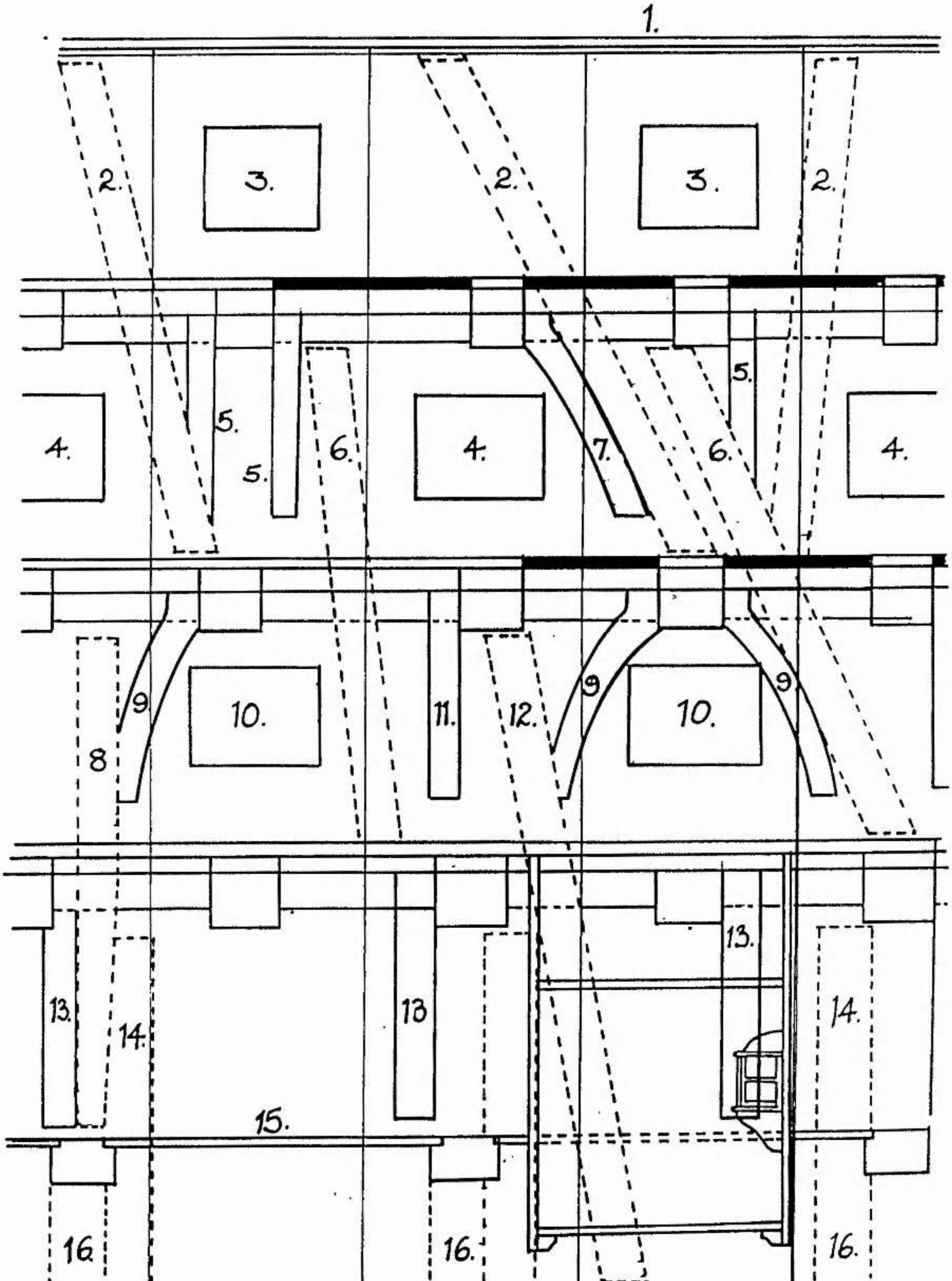

Figure 5/1.

Disposition of Top, Middle and Breadth Riders: Copy of *Victory* Draught c.1787.

Key:

1. Toptimber line.
2. Top Riders.
3. Upper Gun Deck gun ports.
4. Middle Gun Deck gun ports.
5. Hanging Knees.
6. Middle Riders.
7. Side cast Hanging Knee.
8. Breadth Rider.
9. Side cast Hanging Knees.
10. Lower Gun Deck gun port.
11. Hanging Knee.
12. Long Breadth Rider.
13. Hanging Knee.
14. Futtock Rider
15. Orlop Deck
16. Head of Rider

Fig. 5/2. Cross Section of the Victory c.1787-1806 showing Top, Middle & Breadth Riders.

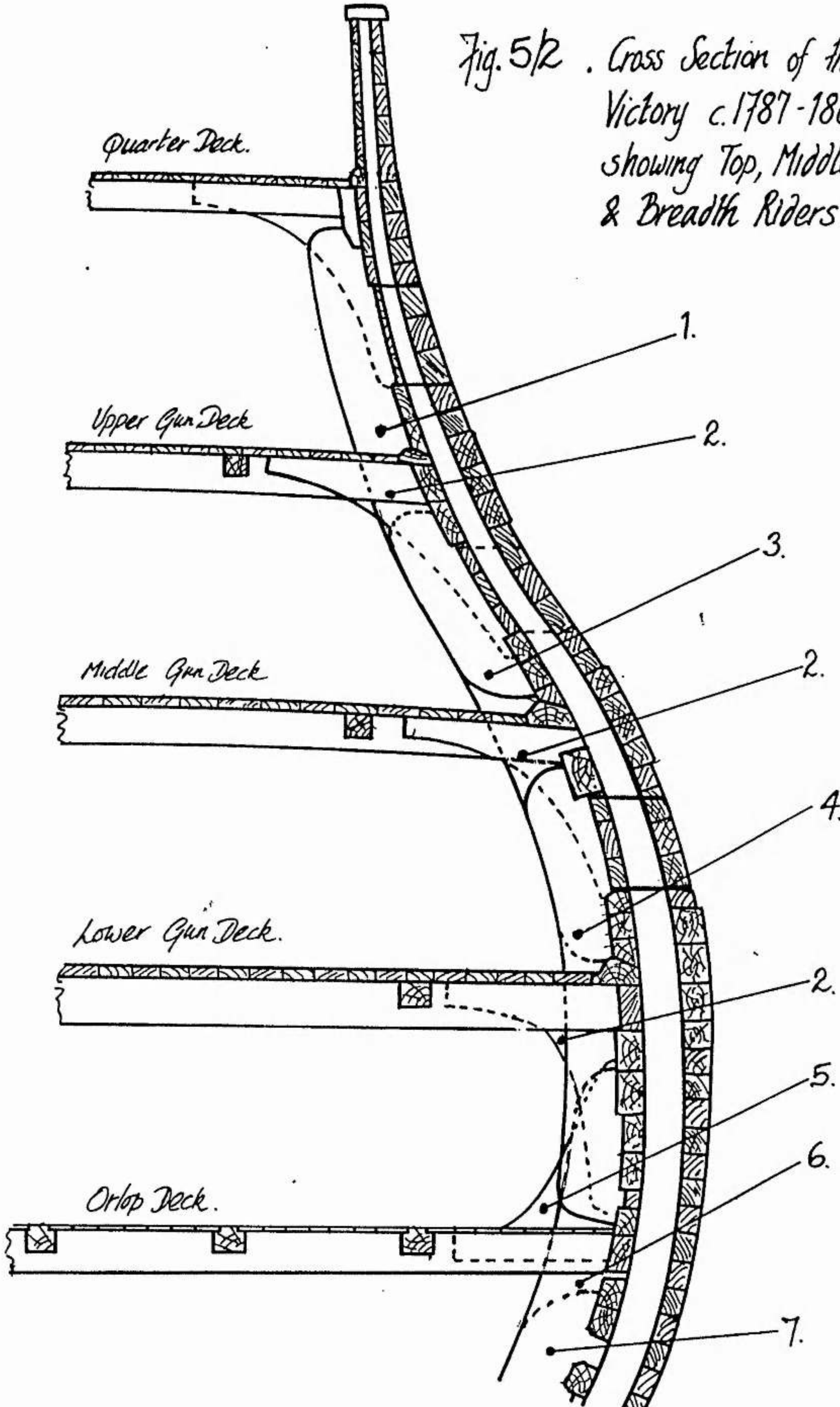

Figure 5/2.

Cross section of the Victory c.1787-1806 showing Top, Middle and Breadth Riders.

Key:

1. Top Rider.
2. Hanging Knee.
3. Middle Rider.
4. Breadth Rider.
5. Standard (or inverted Knee).
6. . Futtock Rider
7. Head of Rider.

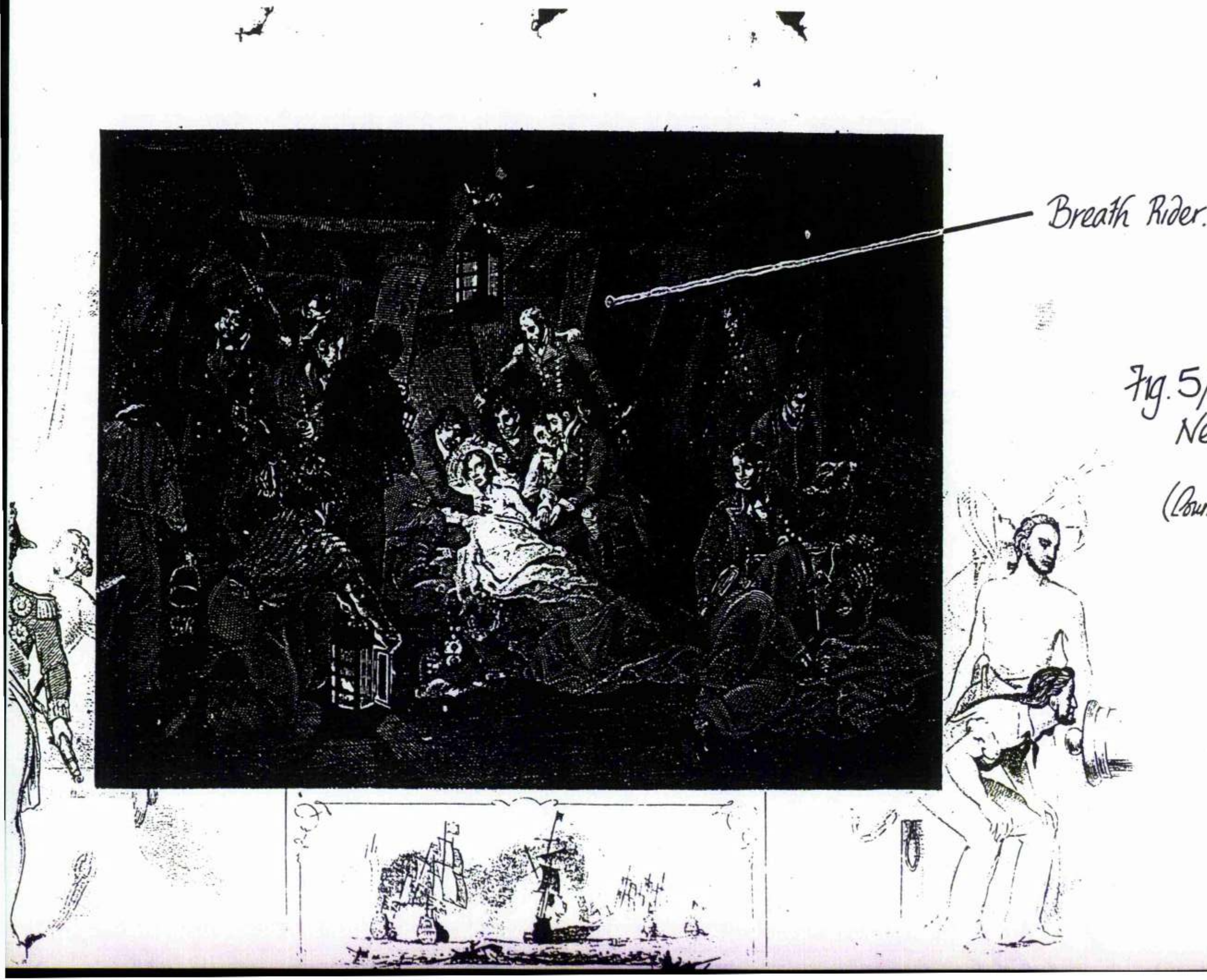

Fig. 5/3. 'The Death of Nelson', by Arthur Devis.

(Courtesy of NMM).

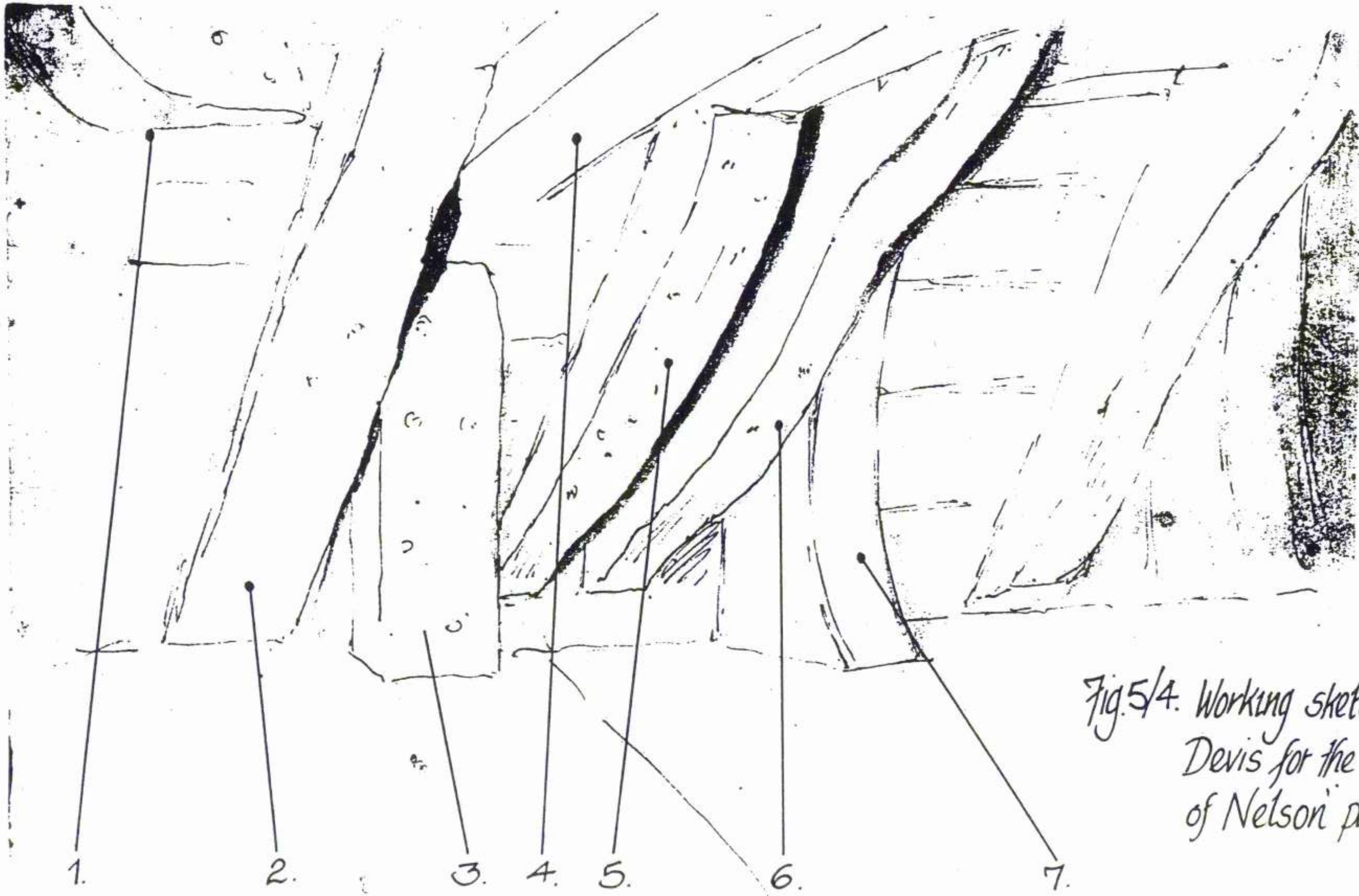

Fig.5/4. Working sketch by Devis for the 'Death of Nelson' painting.

Figure 5/4.

Working sketch by Arthur Devis for the *Death of Nelson* painting.

(Courtesy of the NMM)

Key:

1. Lodging KneeRider.
2. Hanging Knee.
3. Head of Futtock Rider.
4. Lower Gun Deck Beam.
5. Lower part of Breadth Rider
6. Hanging Knee.
7. Standard (or inverted Knee)..

Chapter 6.

The Quarter Deck, Forecastle, and Poop.

Like other pertinent parts of the ship both the quarter deck and the forecastle were modified during the working life of the *Victory*. When first built both of these decks were shorter in length than currently seen. Moreover, both were surrounded with less obtrusive bulwarks.

As in all line of battle ships built during the third quarter of the eighteenth century the fore end of the quarter deck originally ended a little abaft the main mast. The exact point where this deck terminated has, by virtue of consequent alterations, now become somewhat difficult to determine. The factors surrounding this not only relate to beam disposition but also the position of the main mast itself. According to the draught, [1] the main mast was moved aft about 10 inches (25.4 cm) circa 1783. At the same period the length of the forecastle was extended aft by a small degree. This modification appears to coincide with a decision to move the fore mast which was shifted aft 1 foot 9 inches (53.34 cm). [2] Of note, the dimensions given above for these alterations in mast position differ to those given by L G Carr Laughton in his report to the Victory Technical Committee during the 1920s. The above dimensions of 10 inches and 1 foot 9 inches have been taken off the draught. These differ by 2 inches and 3 inches respectively from the original report. At present it is difficult to fully understand why alterations were made to the disposition of both these masts but the reasons must lay behind balancing of the rig. If this was the case then the alteration appears early for any possible authorised change to the general rigging warrants specified for ship rigged vessels, that is ships with three masts; fore, main and mizzen. The bowsprit was never included as a specific mast. The most significant modification that would alter the balance of sail at this period would have been the introduction of the flying jib boom with its corresponding fore and aft sail, the flying jib. This however seems unlikely as the flying jib boom was not officially introduced until circa 1794. [3] The most probable reason was in reality far simpler inasmuch that the alteration was made as consequence to the requirements of the ship's Master whose experience would justify any small change in order to get the best out of the ship. This point has still to be investigated.

When initially fitted out the quarter deck was shorter in length. Fitted either side at the fore end of the deck were two short fixed gangways which were set a little below the level of the deck, these both led to the entry points at the ship's side. They also led to the gangboards that connected the quarter deck to the forecastle, which at the time of construction, were only fitted on a temporary basis. At the centre line was a narrow projection extending forward to the main mast. This was made in the form of gratings supported by longitudinal beams which terminated on the heads of the main jeer bitt pins. When the quarter deck was lengthened beyond the mast the gratings were retained in order that ropework from aloft; i.e. the topsail sheets, could pass freely to its respective belaying points on the sheet bitts sited on the deck below. In recent years these gratings have since been removed and closed in with plank placed to reduce rainwater ingress to the upper gun deck below. Careful investigation of the current disposition of beams and carlings supporting the quarter deck does give some indication of the various alterations made earlier.

Furthermore, irrespective that the deck had been lengthened, the two short gangways, fitted as aforesaid, were retained the only difference being that they were now set level with the quarter deck and terminated farther forward on the aftermost skid beam. Likewise the gangoards were also raised level with both the forecastle and quarter deck but now fitted permanently. What is curious, is that although now raised and fixed permanently to the skid beams, the planking of the gangboards are not laid as a continuation of the respective decks but are retained as individual units indicating that they were still regarded as a separate item. This point may indicate that a small interpretation error may have occurred during the reconstruction process. The fact that the planking is not laid as a continuous unit implies that originally the planks forming the gangboards were actually thinner in scantling. The point that they were later fitted with boards of similar thickness to those planks used for the forecastle and quarter deck relates to the general widening of the gangboards. This together with further lengthening of quarter deck and the forecastle was eventually to lead to the closure of the waist in most ships by 1832. A fine example of this modification was to be seen on the *Trincomalee* (ex *Foudryant*) when employed as a training ship prior to her reconstruction at Hartlepool.[4]

Survey of the beams and carlings supporting other parts of the quarter deck also reveal significant changes which reflect some of the modifications made during the 1800/1803 refit where centre line gratings were removed. This was implemented at Nelson's request to give greater area for operating the guns and conning the ship. Evidence of this can be seen to the fore side of the bulkhead dividing off the Admiral's quarters.

The reason for lengthening of the forecastle c. 1783 is less obvious, there being only two plausible reasons for modification. First, extending the deck aft gave more protection from the weather to gun crews and general requirements on the upper gun deck below. Second, and more significantly, the date of alteration complies to the date that the *Victory* received her iron Brodie stove for the galley. This new form of stove, patented by Alexander Brodie in 1781, [5] became the standard cooking appliance throughout the navy, contracts being set up with Brodie in the same year. Its size, by comparison to the previous form of stove employed, would have meant some alterations to the layout of the galley. Though not significant to the *Victory*, which had her galley placed further below on the middle gun deck, the galley on ships of two gun decks would have been situated directly below the forecastle. This, like other aspects, was another modification indirectly influenced by the progressive steps that had been taken in the iron industry where better and cheaper materials replaced conventional practices. Iron stoves had been used prior to this date but their design and capability did not always fully accommodate the requirements. Brodie, an innovative Scotsman from Peebleshire, had attained the full contract for the supply of iron stoves in 1781 that was to continue until his death in 1811. This contract expanded into other fields such as guns and general iron work. After this a new patent stove introduced by Lamb and Nicholson, which superseded the Brodie design, was installed on the *Victory* during her 1814/16 refit.

Irrespective of the research undertaken regarding the *Victory*, the manner in which her forecastle and quarter deck bulwarks were constructed at the time of Trafalgar still remains a controversial issue. We do know that at the time of her launch in 1765 her upperworks along the sides of the quarter deck and forecastle were very lightly built with open spaces left between the drift rail and planksheer, the drift falling with a hance abreast the main mast. [6] The poop deck was fitted in a similar manner with a shallow rail set about 1 foot (30.48 cm) above the drift. This practice, which was quite common on all ships at that period, did not provide much protection to the men stationed on these decks during battle: protection was only provided by hammocks stowed in nets supported by iron cranes ranged along the upper sides of the rails or along the poop deck. When reconstructed to her 1805 configuration during the 1920s it was decided to build up her quarter deck bulwarks solid, conforming to the contemporary modifications being applied to all line-of-battle ships at the period. The original line of the drift rails, fife rails, and planksheer was retained both internally and externally by use of mouldings. The main contention, which remains unresolved, is whether her forecastle bulwarks were built up in a similar fashion or left relatively open.

Built-up bulwarks had been adopted by foreign navies far earlier than the British. Initially this was confined to the quarter decks only. A fine example of a Spanish vessel so fitted is that of the 28 gun frigate *Grano* captured in 1781. [7] The French had adopted built up bulwarks on both the forecastle, quarter deck and poop of their ships during the last decade of the 18th century. [8] Why the British navy retained open bulwarks for such a long period remains uncertain. What did prompt changes very much relates to the introduction of the carronade. The first indication of building up the bulwarks on British ships appears during the Seven Years War (1756-63). An Admiralty Order, dated May 1760, directed that all frigates furnished with quarter deck 'barricades' were to be reduced in height in order for men to fire small arms. [9] This implies that Captains would, under their own initiative, add some form of protection to the open rails. The next change came with the introduction of the carronade in 1779. This short barreled weapon, which delivered a heavy ball at close range, unfortunately produced considerable muzzle flash which, for obvious reasons, was more detriment to the parent ship than the enemy. To this effect the Navy Board authorised that temporary barricades, made from rope and hammocks, be substituted for timber. [10] The next stage was to berth up the bulwarks with elm boards 1/2 inch (1.27 cm) thick [11] Though not overly protective, this was a move in the right direction, albeit on a temporary measure maintained for the duration of hostilities during the American War of Independence. Once peace was restored, carronades were removed and by an order of June 1786 the temporary wooden barricading was removed. [12] However for other practical reasons, the boarding between the drift and fife rails remained.

The quarter deck was the main area to protect, not only was this the conning position of the ship, it was effectively the main command centre. The first real approach of constructing solid built up bulwarks appears to have been first carried out on the *Endymion* frigate in 1797, following the example of the recently captured French frigate *Pomone.* [13] Once again it appears that French influence altered English ship design. By 1800 most frigates were modified accordingly, some with an additional built-up bulwark fitted at the forecastle, a practice that became standard by 1805. For examples refer to the draughts of the; *Caroline* (36), [14] and *Euryalus (*36). [15]

With regards ships of the line, it appears that the first vessel so fitted with a built-up bulwark on the quarter deck was the *Ajax* (74) launched in March 1798. [16] This is verified from alterations made to the original sheer draught in November 1796. [17] The draught of the *Impregnable* (90) dated 16 February 1798 shows a similar modification to the quarter deck, but no change to the forecastle or poop. [18] Laird Clowes states that this was also carried out on the *Boyne* and the *Union* in 1801. [19] This statement is not quite true for no construction work was begun on either ship until 1806 and 1805 respectively. [20] These bulwarks, which were built parallel to the deck, were generally about 5 feet (1.54 m) in height and finished with a square hancing. [21] Thus it became practice for all ships under construction or refitting to be so fitted, the *Victory* being one. Oddly, although modifications to design were implemented, no reference to built-up bulwarks is recorded by Steel. [22]

When *Victory* was refitted in 1800/03 her existing quarter deck bulwark was removed and built-up solid terminating with a square hance in line with the main mast. This would have involved removing the existing toptimbers and lengthening pieces and replacing them with longer sections of timber. Running parallel to the deck, the bulwark was 4 feet 9 inches (1.45 m) in height. This measurement, taken from recent restoration plans, [23] complies with common practice. Whether her forecastle bulwarks were so built is, to reiterate, a controversial issue; construction was in a transitional phase at this period. Interestingly, an earlier draught of *Victory,* [24] undated but presumed to be circa 1787, is marked up with solid bulwarks on both the forecastle, quarter deck, and the poop. Considering the date it is improbable that this alteration was done at the time, but more likely later; either circa 1800, or prior to her rebuild in 1814/16. If the former, i.e. 1800, then it would appear very plausible that she had solid bulwarks on both quarter deck and forecastle when at Trafalgar. According to the draught, the measurements of the bulwarks are;

Forecastle.	Length: 45 ft. 9 ins. (13.94 m).	Height: 4 ft. 6 ins. (1.37m).
Quarter deck.	Length: 46 ft. 2 ins. (14.07 m).	Height: 4 ft. 6 ins. (1.37m).
Poop deck.	Length: 53 ft. 0 ins. (16.15 m).	Height: 4 ft. 6 ins. (1.37m).

Though the forecastle bulwark was restored to the pre-solid type with protruding timberheads during the *Victory's* restoration in the 1920s, the issue of whether she had a solid bulwark was raised by L G Carr Laughton. [25] The matter was deferred until the Dockyard had assessed estimates to make the alteration. The matter was again raised by Sir George Hope and irrespective of the new plans provided by Professor Callander, and that work had already been undertaken to fit the open bulwark, the proposal to fit built-up bulwarks at the forecastle were rejected on the grounds that additional work was to cost £382. [26] In support of Carr Laughton's theories, the draught of the *Dreadnought,* [27] dated 24th March 1802, is worth analysing inasmuch that this ship was modified with built up bulwarks on both quarter deck and forecastle, the poop being closed with a 'roughtree' rail. Authoritive paintings by Deighton, Dodd, Nicholas and Stanfield imply that the *Victory,* like the *Boyne,* had built-up bulwarks throughout, [28] however we cannot be too certain of their reliability. Likewise, the Carmichael painting in the Royal Naval Museum also depicts the ship constructed in this form. The fact remains that until new documentary evidence is found which confirms exactly how the *Victory* was converted in 1800/03, then the present form of bulwark fitted on the forecastle today is an acceptable compromise that relates to the practices introduced in the *Ajax* and *Impregnable*. Hypothetically, though proposed, the forecastle bulwark may have been omitted as reconstruction costs soared during *Victory's* 1800/03 refit. Moreover, proposed work may have been cancelled in order to complete the refit quickly as the prospect of re-opening war with France became reality.

With respect to a built-up bulwark on the poop stated earlier, this was not the case at Trafalgar. On this issue we do have evidence clarifying precisely what was fitted. The Carpenter's Expense Book for the *Victory* dated 1805 lists the following entry for August;[29]

3rd; To Making new Hammock Boards on the Poop, old decayed.-Deal Brds - Six in No.

That fact that the Carpenter used deal boards implies that the timber employed was probably no thicker than 1.1/2 inches (3.81 cm) which would easily decay, especially after the 'great chase' across the Atlantic. Furthermore, the light construction inferred relates to the point that weight on the upperworks was kept to minimum, and that only the external sides of the iron hammock cranes were berthed up. The more significant point is that the poop deck of the *Victory* had actually been armed with six 18 pounder carronades after her refit in 1782.[30] This date complies with the temporary barricading ordered to be fitted on frigates during the War of American Independence. This also complies with the proposals given on the 1789 draught. In view of the evidence it would therefore seem highly probable that the boarding mentioned above relates to that which was initially fitted to prevent muzzle flash back. Whether the inboard faces of the hammock cranes were similarly furnished is conjectural at this moment. That the ship is not thus fitted in this manner today remains unanswered, especially when there is strong evidence to support this point. In all probability the restoration committee at the time could not make a firm decision.

Although the bulwark configuration of the *Victory* at the period of Trafalgar remains somewhat unresolved, how she was later fitted during her 'rebuild' 1814/16 can be confirmed from other documentary evidence. In all respects the ship was altered to conform with the then current fashion - high bulwarks throughout with the exception of the gangways at the waist, and even these were modified. To fully comprehend trends in construction it is well to look at alternative draughts. With respect to the *Union*, her quarter deck bulwark was 4 feet 9 inches (1.45 m) high rising to 6 feet 2 inches (1.87 m) at the fore side of the gun port just before the break of the poop. The bulwark at the forecastle was 4 feet 10 inches (1.47 m), and that fitted on her poop, 4 feet 6 inches (1.37 m). [31] The dimensions given on the draught of the *Boyne*, [32] dated January 1808, are effectively a mirror of those given for the *Union*.

Further changes were later introduced and probably implemented when the *Victory* was taken in hand in 1823. [33] It was probably during this refit that the poop bulwark was extended forward and terminated with a quarter circle hance. It was also at this period that the hammock cranes and nettings were removed and replaced with the closed wooden hammock stowages similar to those seen on the *Unicorn* frigate today. This, together with the other alterations, altered her appearance to become somewhat more 'wall sided' as seen in all the extant photographs taken before she came into No. 2 Dock in 1922. Though Carr Laughton infers that these changes were made in 1823, [34] it seems odd that such work was undertaken at this period and not earlier in 1816 as one would expect, especially in view that her sea service career was definitely finished. If these alterations were definitely made as late as 1823, then it may well reflect her new role as Flagship for the Port Admiral.

References:

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2. Ibid.
3. Lees, J. *The Masting and Rigging of English Ships of War.1625 - 1860.* London 1979.
4. Goodwin P. *A Treatise on the Laying-up and Resoration of the Ship Foudroyant.* Unpublished notes. 1978.
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6. Laird Clowes, G. S. *Sailing Ships: Their History and Development.* Part 1. London. 4th Edn. 1951. p95.
7. *Grano.* Sheer and Profile. Box 39.NMM.

8. PRO. Adm. 106/2508. 19 May 1760.

9. PRO. Adm. 106/2508. 29 December 1779.

10. PRO. Adm. 106/2508. 19 June 1780. See also: Gardiner, R. *The First Frigates.* London 1992. p82.

11. Gardiner, R. *The Heavy Frigate.* London 1994. p100. See also; Laird Clowes. G. A. op cit. p95.

12. *Caroline.* Lines/Profile. No. 2079 Box. 36. NMM.

13. *Euryalus.* Lines/Profile. No. 2104 Box. 36. NMM.

14. Colledge., J. J. *Ships of the Royal Navy.* Vol. 1. London 1969. p29.

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22. *Victory; Profile Draught of the Inboard works of His Majesty's Ship Victory with the Riders ticked in Red.* No. 206B. ZAZ.0122. NMM. Also Portsmouth Dockyard copy: VR.179. PS.40/01.

23. *Minutes of the Victory Technical Committee.* 30th March 1926.

24. *Minutes of the Victory Technical Committee.* 21st September 1926.

25. *Dreadnought.* Dated 24 March 1802. Sheer/Profile. No.164. Box 4. ZAZ.0196. NMM.

26. Carr Laughton, L. G. *'HMS Victory'. MM.* Vol. X. 1924.

27. *Record of the Carpenter's and Boatswain's Stores and Expenses for the 'Victory', 'Britannia', and 'Africa', for the year 1805.* Royal Naval Museum. 1064/83. 2376. See also; Goodwin, P. Transcription of the above document. 10th December 1992.

28. McKay, J. *The 100 Gun Ship HMS Victory.* London 1987. p19.

29. *Union.* Dated April 1808. Profile. No. 199. Box 4. ZAZ.0247. NMM.

30. *Boyne.* Dated January 1808. Profile. 192. Box 4. ZAZ.0239. NMM.

31. Carr Laughton, L. G. *MM.* Vol. 10. 1924. p188.

32. Ibid.

33. Ibid.

Chapter 7.

Iron Knees, Braces, and Brackets.

Today the hull of *Victory* is braced with considerable amount of iron work, either in the form of Robert's plate knees, various designs of breast hooks and other supportive strapping. Popular consensus is such that most of this iron work was present at the period of 1805, however closer analysis of the ship and supportive evidence suggests that this is not entirely true. What we do see on *Victory* is a transition in ship construction technique, albeit a preliminary countermeasure to strengthen weakened hull fabric, the form of which is merely an improvement on earlier methods.

With exception to bolts and nails and other more minor fittings, the first serious indication we have of iron being used as a substitute for timber components was circa 1670 when the naval shipwright Sir Anthony Deane, a protégé of Samuel Pepys, built the 1st rate *Royal James* at Portsmouth. However Pepys, then Clerk of the Acts, rebuked Deane for using materials not authorised by the Navy Board. After visiting the dockyard, he wrote to Deane stating;

"that you have of your own head, without precedent, as well as without the advice, or so much as the privity, of this Board or the Commissioner upon the place, presumed to lay aside the old secure practice of fastening your beams in your new ships with standards and knees, and in the room thereof taken upon you to do it iron". [1]

Deane, defending the case that his 'iron dogs' were a stronger method of securing beams replied;

"between you and myself, the King must build no more ships, if nothing can be invented but knees..., we having not one knee in the yard". [2]

The King, later seeing Deane's letter, supported his actions. Deane's allegations supported the fact that there was already a serious problem regarding a shortage of timber. In all probability this was incurred by resources being directed towards rebuilding

London after the Great Fire of 1666. Unfortunately we have no knowledge on what the actual iron fittings looked like as the *Royal James* was burnt and sunk at the Battle of Solebay 28 May 1672. That Deane referred to his fittings as 'iron dogs' hints that their design may have been similar to the simple iron clamps found on wrecks at Amsterdam of what is believed to be English colliers circa 1820. [3] In these cases the beams were secured with iron 'U' shaped brackets that embraced the actual ship's frames, the arms being clamped to the sides of the beam. However this supposition is only theoretical, hopefully underwater archaeological survey of the *Royal James* wreck site may resolve this matter. Deane is renowned for his work 'Doctrine of Naval Architecture' published in 1670'.

Although there is no further mention regarding iron fittings in English ships until the introduction of the 1719 Establishment, the French had already begun experimenting with iron knees (courbes de fer) as early as 1707. These were introduced by M. Golbert then Deputy Inspector of Shipbuilding. [4] To what degree French practice influenced English construction has yet to ascertained. The 1719 Establishment specifications include an annex titled. *'Dimension and Weight of Iron Standards on the Gundeck, Middle deck, Upper deck and Quarter deck of Royal Naval ships'.* [5] Of note this list relates to standards (inverted hanging knees) only. From the dimensions given these fittings were of considerable size: i.e. Dimensions of standards fitted on a 100 gun ship;

Extract from Adm.170/429.

Gundeck. Length of the:	*Arm at the Sides…………*	*6 ft 7 ins*	*(2.006 m)*
	Shortest Arm……………	*5 ft 0 ins*	*(1.524 m)*
Thickness:	*Throat…………………………*	*…11 ins*	*(27.94 cm)*
	Next to it ………………………	*6 ins*	*(15.24 cm)*
	At the Ends……… ……………	*3 ins*	*(7.62 cm)*

No. & Size of Bolts:	*Arm to the Side…………*	*4 of 1.1/2 inch dia.*	*(3.81 cm)*
	Beam………	*4 of 1.1/2 inch dia.*	*(3.81 cm).*

Furthermore this source appears to indicate that the specification for iron work was formalised at the time two ships built to the 1706 Establishment, the *Torbay* (80) and *Nottingham* (60), were being rebuilt in 1719. Those fitted on the gundeck of the *Torbay* were 4 cwt. and 2 qtrs. (228.82 kg) in weight, those fitted on the *Nottingham* being 3 cwt. 1 qtr. (165.26 kg) and 2 cwt. 3 qtrs. (139.83 kg). The fact that iron fittings are listed in the Establishment specifications does not infer that they were used extensively in ships. There are many reasons why application was limited, these are; quality of iron, cost, tradition, and personal interests.

At this period, most wrought iron produced was very brittle and subject to fracture. This was mainly due to the impurities introduced from coke during the smelting process. This problem was resolved by Abraham Darby II in 1750, [6] unfortunately little is known about how he applied this new technique. Much of the iron industry was still centred in the south east, Kent, Sussex, and Hampshire, primarily because these areas provided a plentiful supply of wood for smelting. Because production processes were involved, iron remained an expensive commodity for the first half of the 18th century. Costs were also high because a considerable quantity of iron was imported from Sweden and the American colonies; iron from these countries was of far better quality than English iron. However as industrial technology improved change became inevitable.

Shipbuilders, traditionally conservative in attitude, still considered timber preferable to iron and thus were often reluctant to adopt alternative materials irrespective of the advantage. With regards to personal interests, many officials connected with the government, the navy, and the mercantile trade had private involvement with the timber trade, thus it was in their interest to support their investments.

Irrespective of authorised specifications it appears that the design of iron standards and knees varied according to place of manufacture. Evidence supporting this is provided from French sources. In 1733 Blaise Gislain, under instructions from Maurepas, Minister of the Navy, visited the English dockyards of Chatham, Deptford and Woolwich to make observations of our ship construction techniques. His report clearly indicates variations in the design of iron standards; those made at Chatham and Woolwich being rather plain with a thick throat, that from Deptford being braced with a curved stay. [7] **(Fig. 7/1)** He also records a form of bracket, or iron dog, used to retain deck beams, **(Fig. 7/2)**. Subsequently, the French improved the design and adapted iron fittings in place of timber to their ships more readily than the English. Such modifications, introduced by Duhamel Du Monceau are clearly shown in his treatise published in 1752. [8] Knees illustrated in Duhamel's treatise **(Figs. 7/3 & 7/4)** are formed from three pieces of flat iron bar, some being a complete angle with a stay. Others have the angled corner omitted, the beam being additionally supported with a second plate fitted underneath, its vertical arm abutting the ship's side. Knees of the same fashion were being manufactured at Brest under the authority of Deslongchamps in the same year. In 1754 the English shipwright Mungo Murray translated and published Duhamel's treatise. [9] This was to be the first serious English doctrine printed since Sutherland's works of 1711 and 1717. [10] This work, together with the capture of the *Invincible* and the appointment of Sir Thomas Slade as Surveyor of the Navy in 1755, very much influenced English opinion in design, materials, and construction techniques.

The iron fittings illustrated in Duhamel's treatise closely resemble the iron knees found on the wreck of the *Invincible* (74) which foundered and sank off Spithead in 1758. Designed by M. Morineau, and launched at Rochfort in 1744, this vessel, was later captured by Anson at the Battle off Cape Finisterre in May 1747. The *Invincible* was built with quite a number of iron knees, some of which were boxed in with timber, a system of which predates any similar practice adopted on English ships. All of these iron knees dated from her construction 1740-44. In size the length of the iron knees fitted on *Invincible* **(Fig. 7/5)** measure approximately 5 ft 5.1/2 ins (1.67 m), the metal being 4 ins (10.16 cm) wide and 1.1/2 ins.(3.81 cm) thick. [11]

Iron fittings soon influenced current building trends especially with the ever increasing problem of procuring good compass timber for knees and riders, etc. towards the end of 18th century. This problem was expounded especially during the French Revolutionary and Napoleonic Wars when there was necessity to expand warship construction. Besides the improved smelting process aforesaid, other developments were happening in Britains's iron industry. In 1754 the first iron rolling mill was opened at Fareham producing stronger iron bar for bolts. Importantly, this is a site not too distant from the Royal Dockyard at Portsmouth.

The greatest breakthrough in technology came in 1784 when Henry Cort of Gosport patented a new method for converting pig iron into malleable wrought iron in a reverberatory furnace heated by common coal. The process involved a 'puddler' to stir the molten mass. As it was stirred the metal was decarbonized by air circulating through the furnace. The major advantage was that the iron remained separate from the coal fuel. This innovation was not entirely acredited to Cort, as similar processes had been tried previously by both the Cranage brothers at Coalbrookedale and by Peter Onions. [12]

After further experimentation, Cort invented a new method of making better quality iron bar and eyebolts, etc. using grooved rollers which he patented in 1783. Instead of the old process of hammering or cutting rolled plate in a slitting mill, Cort's system could produce about 15 tons of iron bar in 12 hours. [13] Stronger iron bolts were very necessary to ship construction especially with the introduction of plate knees, etc. He then went on to provide stronger anchors for Naval ships.

To assist Cort's experiments, old iron ballast was supplied to his foundry at Funtley near Fareham from Portsmouth Dockyard. Experiments, in the form of destructive testing, were carried out at each Royal Dockyard comparing items manufactured with Swedish iron and Cort's iron. In March 1787 the results were published in a report supported by Lord Sheffield, David Hartley Esq. and Dr. Black (see Chapter 8). [14] The processes involved are superbly recorded in an extract of Hartley's letter dated 19 June 1786, enclosed within this report.

The overall result proved that lower grade English iron could be converted to a malleable iron far stronger than that of better quality iron supplied from Sweden. This fact is clearly emphasised from part of the report;

EXPERIMENTS made at WOOLWICH Dock-Yard.

SWEDISH IRON	*CORT's IRON.*
An anchor 43 cwt. 2 qrs. 14 lb.	*An anchor 44 cwt. 3 qrs. 0 lb.*

On the ninth of May, the arms of the two anchors were placed over the sides of two building slips which lie parallel to each other, (chocks........) and the shanks lay horizontally, with the rings opposite each other; the straps of two treble fall tackle blocks were then put through the rings of each anchor, and wood toggles run through the straps to secure them to the rings; a twofold block was likewise secured to each ring, to increase the purchase; the other two blocks were fastened to each end of the treble tackle falls, they being first reeved through two single blocks, lashed to bollard heads. To lead them to the capsterns which were manned with thirty-six men each after a very great strain.

The ring of this anchor broke in three places, a piece 2-5ths of the circumference of the ring being separated from it entirely, and that piece broken again nearly off in the middle. In other respects the anchor remained in the same state as after the former trial.	*The ring and every other part of this anchor remained precisely in the same state as before either of the trials.*

Not only had the quality of iron improved, the concept of using iron had now became more appreciable especially as production had increased rendering it a more cost effective commodity. This could not have come at a better time, as besides Sweden, and occasionally Spain, our other substantial source of iron had been supplied from the American Colonies. As a result of the War of American Independence this source had been briefly interrupted. The rules governing the export of iron from the American Colonies, introduced under the Iron Act in 1750, were along with many other factors, a contributory point of contention that initially lead us into the war. Irrespective of our own expansion Swedish iron, timber, and other raw materials supplied from other Baltic States continued to be imported. So necessary were these materials for our shipbuilding industry and war effort that trade had to be given considerable protection during the pending wars with France (1794-1801 & 1803-1815).

Taking advantage of new technology, Gabriel Snodgrass, the Surveyor of the East India Company introduced an innovative system using iron knees, riders, and braces to the new EIC ships being built in the 1780s. **(Fig. 7/6)** Finding his scheme successful, he submitted his proposals before the Admiralty in 1792. From contemporary publications it appears that it was at this point that Britain took the lead over France on the extent that iron was employed in ship construction. [15] **(Fig. 7/7)** This was due to three factors: France was financially crippled after supporting the American cause; industrial development was thwarted by the revolution; and last, Cort's puddling process was not introduced in France until circa 1818. [16] Though no immediate action was taken by the Admiralty at this stage, it appears that Snodgrass's ideas greatly influenced subsequent designs submitted by Robert Seppings who was later to become the Surveyor of the Navy in 1813. Iron fittings, based on the Snodgrass system, appear to have been adopted on warships circa 1795. These, introduced by the sub-surveyor Mr. Roberts, comprised a combination of wooden chocks braced with iron plate knees. [17] The advantage of such a system was that surplus short lengths of straight grained wood could be utilised without wastage, a very important issue by this period. Such a design can be seen on the *Victory* and *Trincomalee* today. Their use however should be regarded more as a structural repair or strengthening measure fitted to existing ships rather than a formalised building practice. Besides Roberts, other similar designs were submitted though how extensively they were used is undetermined. [18] It was to be a further decade before iron knees were formally introduced by the Navy Board Order of 6th May 1805. [19]

By 1801, the dockyards were now using some 1400 tons of iron annually. [20] To meet this requirement Dockyard facilities had to be upgraded. In 1797, a weighbridge was constructed at Portsmouth Dockyard to ensure that incoming loads from contractors were correctly measured. Likewise all iron bar supplied was cut to expose its end grain and often further examined by heating the ends and beating the material to test tensile strength. Use of iron was not restricted to ships construction but other lesser fittings. A new Iron and Brass Foundry was built within Portsmouth Dockyard 50 yards north of the Block Mills. During expansion in 1803, a new furnace was installed for smelting iron and copper. With the Block Mills now operational, a metal mill was set up incorporating purpose built machinery designed by Brunel to produce iron pins for the blocks. This was opened in 1806. And thus, the technical infrastructure of Portsmouth Dockyard moved steadily towards the iron ship building era. A similar process was undertaken at other key Royal Dockyards. [21]

Production of pig iron in England rose slowly from 17,000 tons in 1740 to 45,000 tons in 1785 - the time of Cort's innovation. After this date growth increased rapidly arising to an annual output of 700,000 tons by 1830. And within a further nine years production reached 1700,000 tons, an increase of one hundred percent over a century. [22] This fact very much reflects the advantages gained by Cort's puddling process. Besides industrial expansion import restrictions caused by war also generated greater use of English even while iron was still imported from Sweden. Obviously it was imperative to maintain open trade links with the Baltic. However these were threatened on two occasions.

The first was caused by the Armed Neutrality - formed by the Baltic states of Denmark, Sweden, Prussia and Russia. This coalition was coerced by Napoleon to ensure neutral ships ignored the British right of search. In brief this would effect Britain's trade supplies and assist trade to France and Spain. Inevitably this forced Britain to use alternative sources and now that relations with the former Colonies had improved, iron, and other necessary ship's stores such as masts, tar, and turpentine, were again being sent from what was now the United States of America. However, the northern coalition was soon broken with the defeat of the Danes at the Battle of Copenhagen by Nelson in 1801. This effectively brought Napoleon to heel and subsequently the war closed with the signing of the Treaty of Amiens in March 1802.

Peace was not to prevail, with the failure on both sides to adhere to the recent treaty the war reopened in 1803. Baltic supplies remained restricted, only 11,000 ships passing through the Sound in 1805. This figure had fallen to 6,000 by 1807 the decrease being mainly due to Napoleon's enforcement of the Continental System which banned all European trade with Britain which effectively reduced the import of crucial supplies.

After the destruction of the Danish fleet at Copenhagen in 1807 a potential threat and assistance to Napoleon was removed. From then onwards the import problem began to improve, and to counteract any further restrictions, the theatre of war was expanded into the Baltic with a British fleet led by Admiral Saumarez in the *Victory*. Saumarez himself re-opened diplomatic relations with Sweden ensuring that the export of iron and other raw materials to Britain was maintained. By 1809 the trade situation had considerably improved, and by 1812, regular supplies of raw materials, including iron were provided to the dockyards. [23] In consequence, the use of iron in ship construction and fittings increased.

During the war, the scarcity of timber had become a relatively acute problem. Attempts were made to use alternative woods such as fir and beech but these did not prove overly successful, and although introducing iron fittings would alleviate matters, the situation was further exasperated by the reservations raised by the Navy Board in April 1804. To quote "However eligible plans which have from time to time been suggested , the result has not always answered the expectations formed from them", and the Board should, *"act with caution"*. They advised the Admiralty that, and I quote, *"previous to the adoption of any general plan which has not the authority of practice, to prove the utility proposed by it however plausible it may be in appearance"* [24]

The fact that no formal introduction of iron was made until 1805 is supported from draughts of the *Caledonia* (1807), [25] and a draught showing the modifications made to the *Union* in 1810. [26] From this evidence it is clear that the existing iron plate knees currently seen on the *Victory* today, were not extant at Trafalgar but introduced during her 'great repair' of 1814. This point is wholly substantiated from Devis's painting of *'The Death of Nelson'*. This well documented painting [27] clearly indicates that the gun deck beams were still supported with wooden hanging and lodging knees. In addition other fittings, now non-existant, are also shown (see Chapter 10). Unlike new ships built, iron plate knees fitted on the *Victory* were only placed at selected areas: Middle Gun Deck **(Fig. 7/8)**, and Orlop. **(Fig. 7/9)** Those fitted on the former deck, which supported the upper gun decks beams, are only found at every other beam, the remaining beams were furnished with the older system using hanging and lodging knees. This point infers the following;

1. When refitting 1814/16, only half of the upper deck beams were replaced incorporating the fitting of beam end chocks and plate knees.

2. The practice of only altering every other beam could have been undertaken to keep costs of timber and iron work to a minimum.

3. Beam replacement complies with all those fitted under the upper deck gun ports thus the new method was adopted where greater strength was required to support the ordnance.

4. The practice of only altering every other beam could have been undertaken to ensure maintaining the line of the deck. Such measures are still carried out today when restoring the ship's frames where alternative defective frames are removed over a given span. When replaced and lined with the original frames, the remaining old frames can then be removed and new fitted and lined with the new frames previously replaced. This method ensures that the run of the hull shape is never compromised.

In short it appears that a good compromise was taken between improving strength and cost. The point stated in 4 above complies with standard ship repair practice. Recent survey has shown that those beams supported using wooden knees were found be in a greater state of deterioration than those beams fitted with chocks and plate knees. This fact confirms that the latter stated are considerably newer.

The average dimension of the iron plate knees fitted on the range of the middle gun deck were found to be 3 ft. 4 ins (101.60 cm) long on the athwartships arm and 3 ft. 8 ins. (111.76 cm) long on the 'up and down arm'. The width of the plate arms varied. The athwartships arms measure 4 inches (10.20 cm) wide, the remaining vertical and angled arms being 3.1/2 inches (9.00 cm) wide. Metal thickness is 2 inches (5.08 cm) at the throat tapering to 3/4 inch (1.91 cm) at the extremities. Each were fastened with 11 bolts; 4 in the athwartships arm, 2 in the angled portion forming the lodging knee, 4 in the vertical arm and 1 in the angled arm. The entire thickness of the plate knee was found to be set into both the beam and chock, the exception being the lodging arm which is fayed and bolted to a packing piece. Furthermore, the athwartships arms are fashioned with two lugs about 4 inches (10.20 cm) wide and 2.1/2 inches (6.35 cm) deep. These provided an increase in metal width to permit better security in wake of bolts. This particular design, which does not exist on any other preserved vessel, is a rather unusual feature. Each plate knee is secured with 11 bolts two of which are driven through the lodging knee portion. Chock knees in wake are checked into the underside of the beams in such a manner that a fore and aft slot was formed between the upper surface of the chock and lower face of the beam. This was made in order to fit opposed iron wedges that they can be tightened if components worked loose at sea. The slot itself is lined with a copper sleeve. [28]

With regard to the beams of the quarter deck and forecastle, these remain supported with standard wooden hanging knees with some iron lodging knees. More odd is the fact that middle gun deck beams remain supported with wooden hanging and lodging knees. This implies that none of these beams were replaced since circa 1803 until restoration was undertaken between 1989 and 1994 from No. 1 to 12 beam.

The iron knees wrought in wake of the lower gun deck beams differ slightly in design from those fitted on the middle gun deck inasmuch that there are no lugs and thus their manufacture is much simpler. These measure approximately 4 feet (121,9 cm) in length and depth; the vertical, horizontal and angled arms being 5 inches (12.7 cm) wide; metal thickness varies from 1.1/8 inches (2.85 cm) at the extremities, the throat being 3 inches (7.62 cm) thick. Each are secured with 11 bolts, two of which pass through the portion forming the lodging knee. As previously mentioned the thickness of metal is recessed into the adjacent woodwork of the beam and beam end chock. Likewise all are furnished with opposing iron wedges within a copper lined slot. 'Rase marks' on relevant beams and chocks indicate that this work was undertaken during *Victory's* 1814/16 refit. The design of these iron knees correspond to those fitted on the *Trincomalee* frigate of 46 guns which was launched at Bombay in 1817, **(Figs. 7/10 & 7/11)**. The fact that this ship was under construction while *Victory* was being extensively rebuilt confirms that by this period a common pattern of iron plate knee had been adopted in all naval ships.

As stated there is a difference in the design of the iron plate knees between those fitted supporting the lower gun deck and those of the upper gun deck. This fact does suggest that each type may have been installed at different dates, the latter stated possibly being earlier in 1810. This point could be verified by the fact that the iron knees supporting the upper gun deck are fashioned with lugs, a feature similar to those previously introduced by Snodgrass, however further analysis is necessary before this point is fully confirmed.

When iron bracing was fitted between the heels of the counter timbers and the wing transom on *Victory* is at present uncertain but again certainly later than *Victory's*. 1800/03 refit. The square stern, which had changed little since the Tudor era, was not itself an overly successful design. Later Sir Robert Seppings was to strongly criticise stern construction as seen by the content of his letter [29] submitted to Lord Melville 1st January 1822. This paper, which lists defects observed from some 62 line-of-battle ships and 80 frigates, includes the *Victory* herself; [30] For details refer to table on next page.

No. 1 - Ships referred to in the preceding Letter.

Rate	Guns	Ships Names	Captains Name	Date	Nature of Defect.
2	98	London	Griffith	Dec 1795	"The stern works and strains when blowing fresh from the quarter. Find that by the ships getting aground, her stern-frame is very much broke and strained. The carlings of the lower-deck have worked out of their scores in the transom."
3	64	Asia	McDougall	Dec '95	"The poop works work very much."
"	74	Colossus	Jenkins	Jan '96	"Wales, topsides, stern frame and standards, work very much."
"	64	Africa	Horne	Aug "	"The poop and knees in the great cabin work very much at sea."
1	**100**	**Victory**	**Grey**	**Sept "**	**"I have also observed that the ship is very weak abaft; the transoms between the lower and middle-decks work exceedingly."**
3	64	America	Blankett	Dec "	"The heels of the stern-timbers almost worked out their steps."
1	100	Queen Charlotte	A. S. Douglas	Jan 1797	"The stern-frame works so much, it breaks the wooden ends of counters and buttock seams. The tiller transom works very much."
3	74	Cumberland	Rowley	ditto "	"The stern-timbers work very much in their scores in the wing-transom."
"	"	Venerable	Fairfax	Sept. "	"The counter-timber-heels worked out of their scores in the wing-transom."
"	64	Agamemnon	Fancourt	ditto "	"The ship has dropped so much abaft, that the tiller traverses entirely on the helm-transom, and it is supposed that the stern-post works.

The gravity of the problem can be seen from the short extract above. The problem was further expounded by virtue that the stern of all two and three decked ships were constructed with open galleries which added unnecessary weight abaft the hull line. Well aware of the inherent failures of stern construction design the Admiralty and the Navy Board abolished galleries and introduced the closed stern 1798. This action alleviated the problem temporarily but it was to be a further two decades before Seppings revolutionised design. Following this trend, the *Victory* was rebuilt with a Closed Stern during her 1800/03 refit. The additional iron bracing that we currently see today would not have been fitted at this stage but incorporated in 1814/16 or later. This statement is supported by the fact that analysis of the various iron straps and brackets fitted **(Figs. 7/12 & 7/13)**, within the various after cabin areas (Captain's, Admiral's and wardroom) reveal that all iron work is, by virtue of the gauge of metal employed, very much characteristic of the bracketing later introduced by Seppings circa 1820. [31] If not fitted during her rebuild it may well have been fitted in 1824 when *Victory* was being furnished out as the port admiral' s flagship. Bracing with iron was the only short term solution. Like Snodgrass, Seppings advocated using iron on a considerable scale.

Once Seppings had taken office, he could introduce his innovations that would revolutionise ship construction. The use of iron plate knees **(Figs. 7/10. 7/11. & 7/16)** with wood chocks, clearly seen in the construction of the frigate *Trincomalee* built in 1817, had now become standard shipbuilding technique. With timber conservation in mind, this practice was soon superseded by forging a complete iron knee in the form of a bracket without the angled stay which thereby virtually eliminated the use of the wooden chock and required only a packing piece. The design of these knees varied accordingly to their application as seen on the *Unicorn* frigate **(Figs. 7/14 & 7/15)** built in 1824, and to reiterate, the iron bracketing employed supporting the stern timbers of the *Victory*. By this period iron was also being used for, deck hooks, breast hooks, and crutches. thus giving greater support to the fore and after ends of a vessel. Their "introduction eliminated the necessity to employ large pieces of compass oak previously used, the size of which had always been difficult to procure. [32] This practice was earlier used as backing plates to strengthen breasthooks, etc. fitted in the *Victory* in 1814. More unusual is the plate fitted on the upper surface of the breasthook fitted at the fore end of *Victory's* orlop deck. Inspection confirms that this fitting complies with Seppings designs. [33] **(Fig.7/17).**

The use of iron was to have an even more profound effect on ship construction. On the 10th March 1814, Seppings addressed his paper on a *'New Principle of Constructing His Majesty' Ships of War'*, before the Royal Society. [34] Using the principle of a 'five barred gate' Seppings showed that ships could be built more rigid. The current construction system, which relied entirely on the cohesion of transverse frames and beams, and longitudinal strength members and planking, was, because forces acted in two planes only, susceptible to 'hogging' and 'sagging'. In both cases, the strength of a ship's hull is compromised due to the flexing incurred: Seams would open up easily and decks move out of true; the hood ends of hull planking could be forced out of their rabbets. To compensate, the initial practice was to use wooden breadth, top and middle riders, each fitted against the ships side, spanning two deck levels. This is clearly seen on an updated draught of the 98 gun *Dreadnought,* [35] and evidence that *Victory* was so fitted is indicated in the well known Devis painting aforementioned. In short, Seppings proposed that the inherent transverse forces would be counteracted if a hull was braced with diagonal laid riders.

The principle of diagonal bracing was first , "successfully adopted in the 74 gun ship *Kent* in 1805". [36] Seppings later improved this design by fitting diagonal timbers between the gun ports and fitting diagonal carlings between beams and laying diagonal deck planking. This became universally known as the 'trussed frame' system. [37] This was not an entirely new innovation as diagonal riders had been used experimentally before both in France [38] and America, though not on a wide scale. The USS *Constitution* of 1797 itself is a surviving example and recent reconstruction has incorporated such timbers in accord with Humphries' specifications. [39] One advantage of Seppings design was that short lengths of timber could be used thereby reducing timber wastage. Seppings also introduced a method of stiffening a hull by inserting opposed wedges in the spaces between the floor timbers thereby producing a continuous rigid form. It was now but a short step before the diagonal timber riders were substituted with those of iron. A classic example of diagonal iron bracing can be seen on the frigate *Unicorn* now at Dundee, **(Fig.7/18).** This vessel, built at Chatham in 1824 is the archetype of a ship encompassing Seppings innovative designs: the round bow, round stern, iron knees **(Fig. 7/19),** riders and stanchions, and built-up solid bulwarks. The original timber crutches and breasthooks used on both the *Victory* and *Trincomalee* were now made entirely of iron giving greater strength afore and abaft. The overall effect of Seppings' work was that ship length was now less restricted and in 1832 a new class of ship was introduced, these having 90 guns, mounted on two decks only as opposed to the 3 decked 90's some thirty years earlier.

Prior to this other proposals were submitted in an effort to reduce hogging. One such innovation comprised fitting 'U' shaped iron braces set between the main frames in wake of gun port sills and ledges. Whether this rather unique system was actually adopted on any particular ship as an experiment is now speculative and may have been abandoned in view that it was both complicated and expensive. [40]

Higher production of cheaper and better quality iron soon lead to the construction of iron warships, the first, HMS *Warrior*, completed in 1860. This revolutionary step in ship development heralded the eclipse of the traditional wooden man-of-war which had reigned supreme since the Tudor period. However there is an ironic conclusion, inasmuch that the concept of adopting iron with timber construction, albeit first initialised without authority by Sir Anthony Deane in 1670, was later utilised, together with Seppings principle of diagonal timbers in the design of Scott's *Discovery* built in 1901. This vessel, now preserved at Dundee, was purposely constructed to withstand the rigorous environment of Antarctic exploration. What is less obvious is that the introduction of iron fittings, in whatever form, based on the Seppings system permitted even greater changes: The advent of steam propulsion, with its weighty machinery, boilers, and its extensive paddle or propeller shafting required a stable platform to give it considerable support. This necessity could only be provided from a rigid hull form braced by iron.

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Fig. 7/1. Gislain's notes. c. 1733.

[illegible]

Courbe [illegible], Si il [illegible]

plus Des Courbe de fer [illegible]

[illegible]

[illegible] pour [illegible]

Les planches [illegible] 15 [illegible]

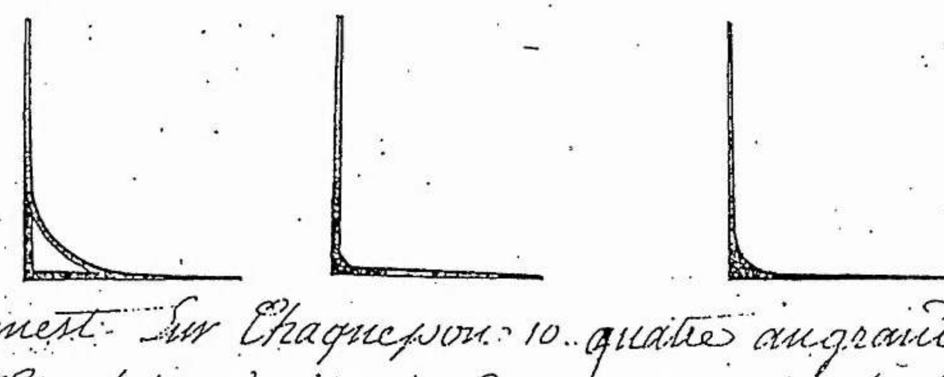
-[illegible] que [illegible] pour Tous vaisseaux, ces

Courbe Sont Differemment Taillés de ceux qui Se font

En france Et [illegible] Chaque [illegible] de Depfort. Woolwic

Et Chatam on Chacun leur façons de les faires.

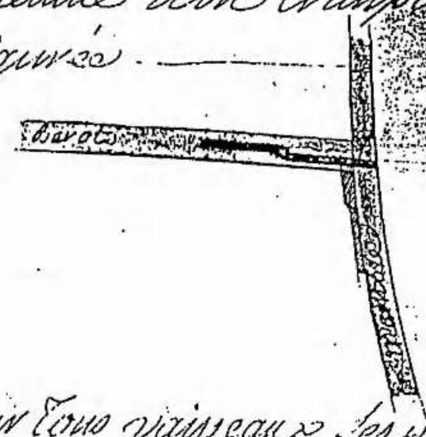
Depfort. Woolwich Chatam. —



Lon En met Sur Chaque pont 10. quatre au grand mast Et a celuy de misenne, Et 2 au travers de ~~Sartine~~ Sartimons. Tant Sur le premier, que Sur le 2.e Et 3.e pont. Bonne Courbe point les Barots des gaillar

Fig. 7/2. Gislain's notes, c.1733.

qui se trouve Dans le Chambre Et dememe Tous ce
Dunette, il Sont Liees auec les Costes par Des Trav
Sairs Et Enchasché dans les Barots de leur Epaisseu
Et chevillée auec de 3. Cheville Et un Crampons
Sont Comme si dessou figurée. ——



De regle generalle pour Tous vaisseaux les prem
pon sont Entierement Bordé de chesne. Et les
De planche De prus, Les arboulans Et Barotins Entr
Baux Du premier pont sont De chesne. Et ceux
autre pont. Le gaillard de Sapi. Les Bordages des
pont sont Cloués Sur les Baux Et garnables. Sur les
Barotins Et pour Tous ces ponts Et gaillard
sont Cloués Tous Sur les Baux que Sur les Barotins.

Fig. 7/3. Extract from Duhamel du Monceau's Treatise on Naval Architecture. 1752

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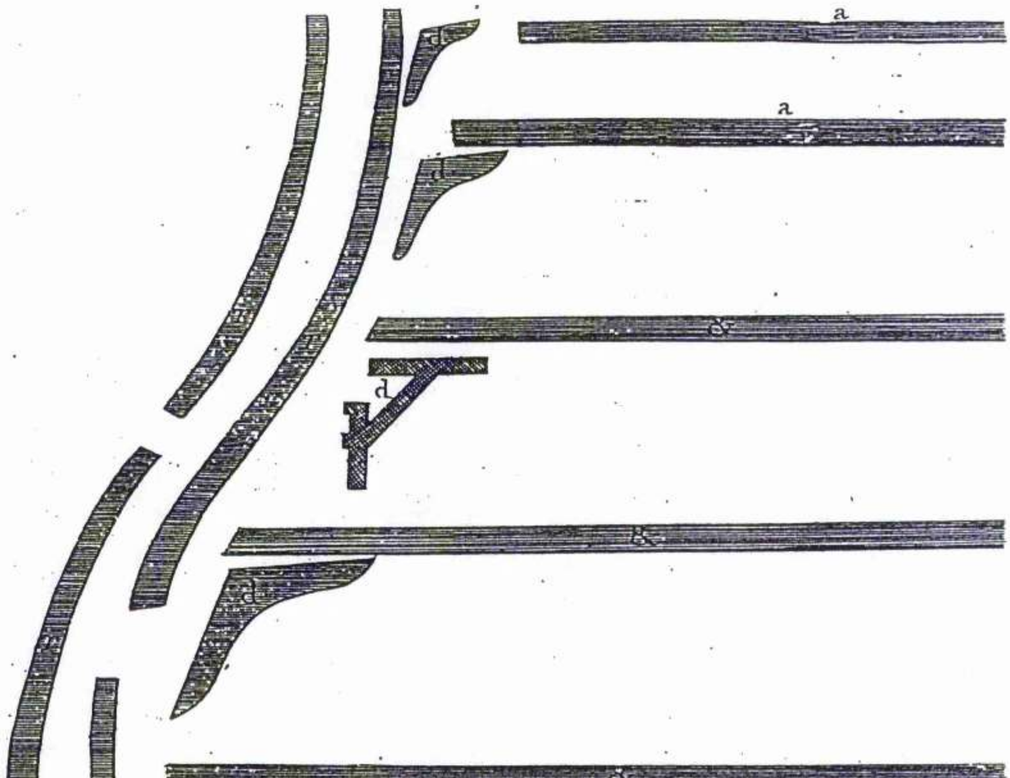


Fig. 7/4. Extract from Duhamel du Monceau's Treatise on Naval Architecture 1752.

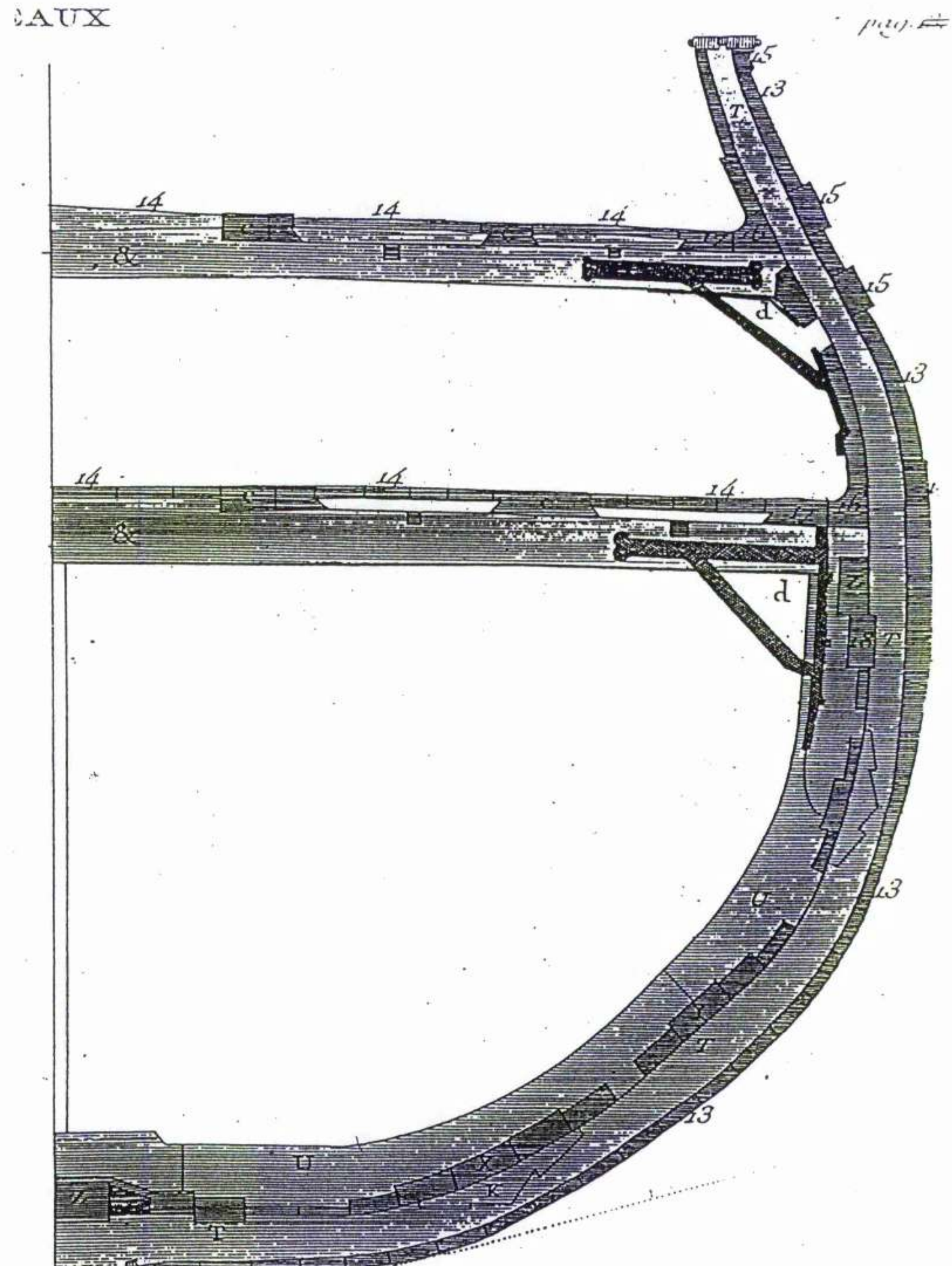
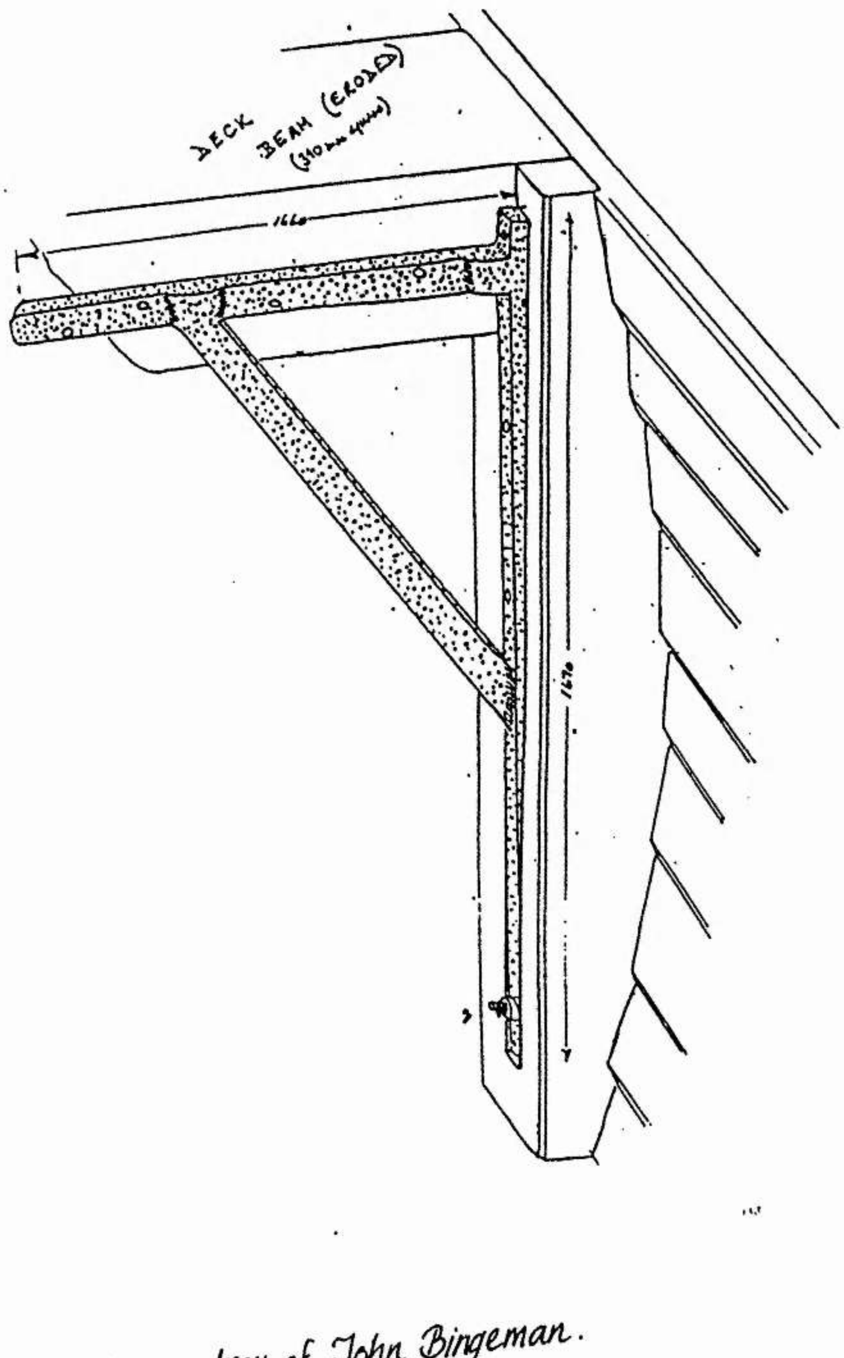


Fig 7/5. Iron Knee from the 'Invincible'.



By courtesy of John Bingeman.

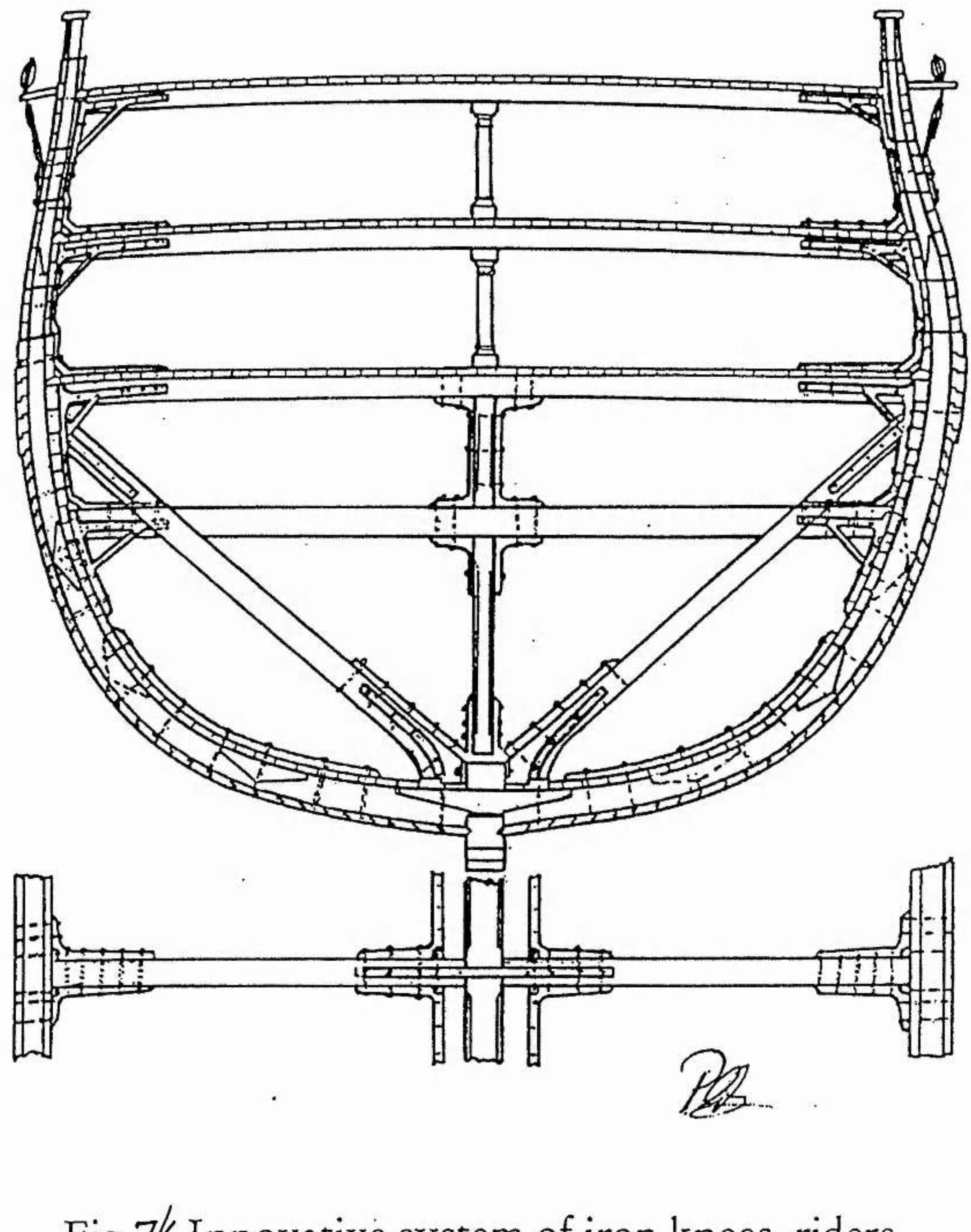


Fig. 7/6. Innovative system of iron knees, riders and braces introduced by Gabriel Snodgrass.

Fig. 7/7. Recueil De Planches c.1785

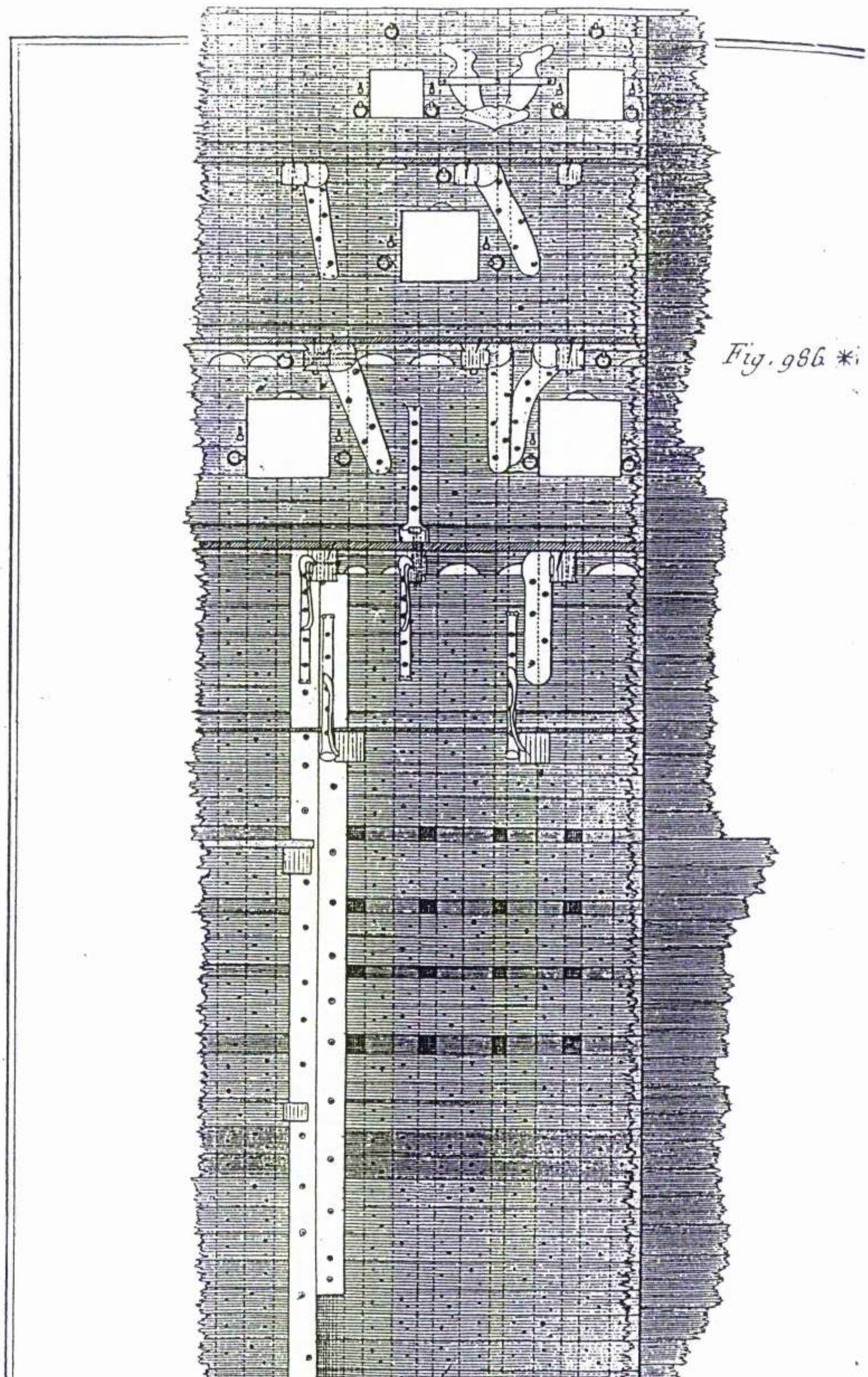


Fig. 986 *

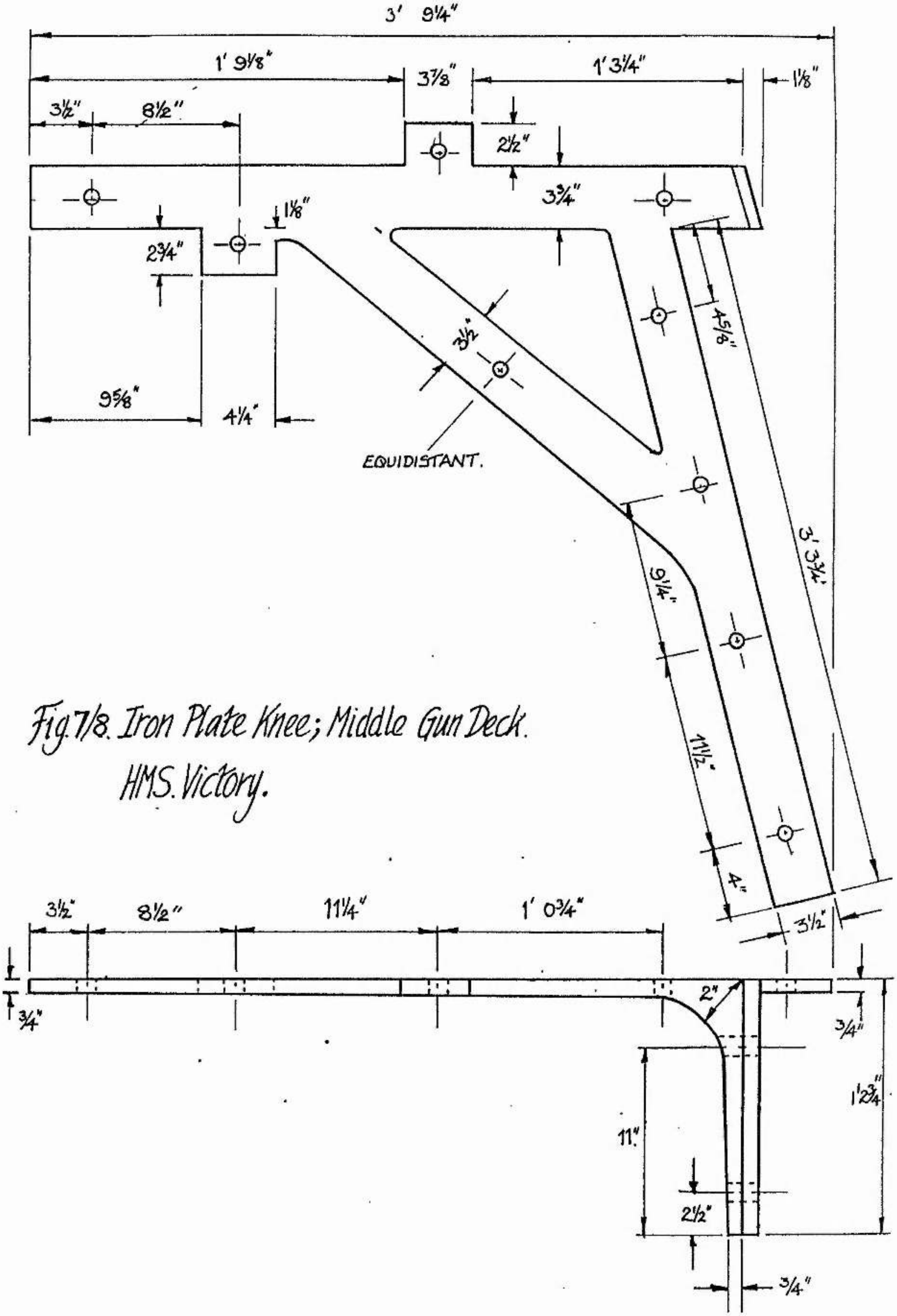


Fig. 7/8. Iron Plate Knee; Middle Gun Deck.
HMS. Victory.

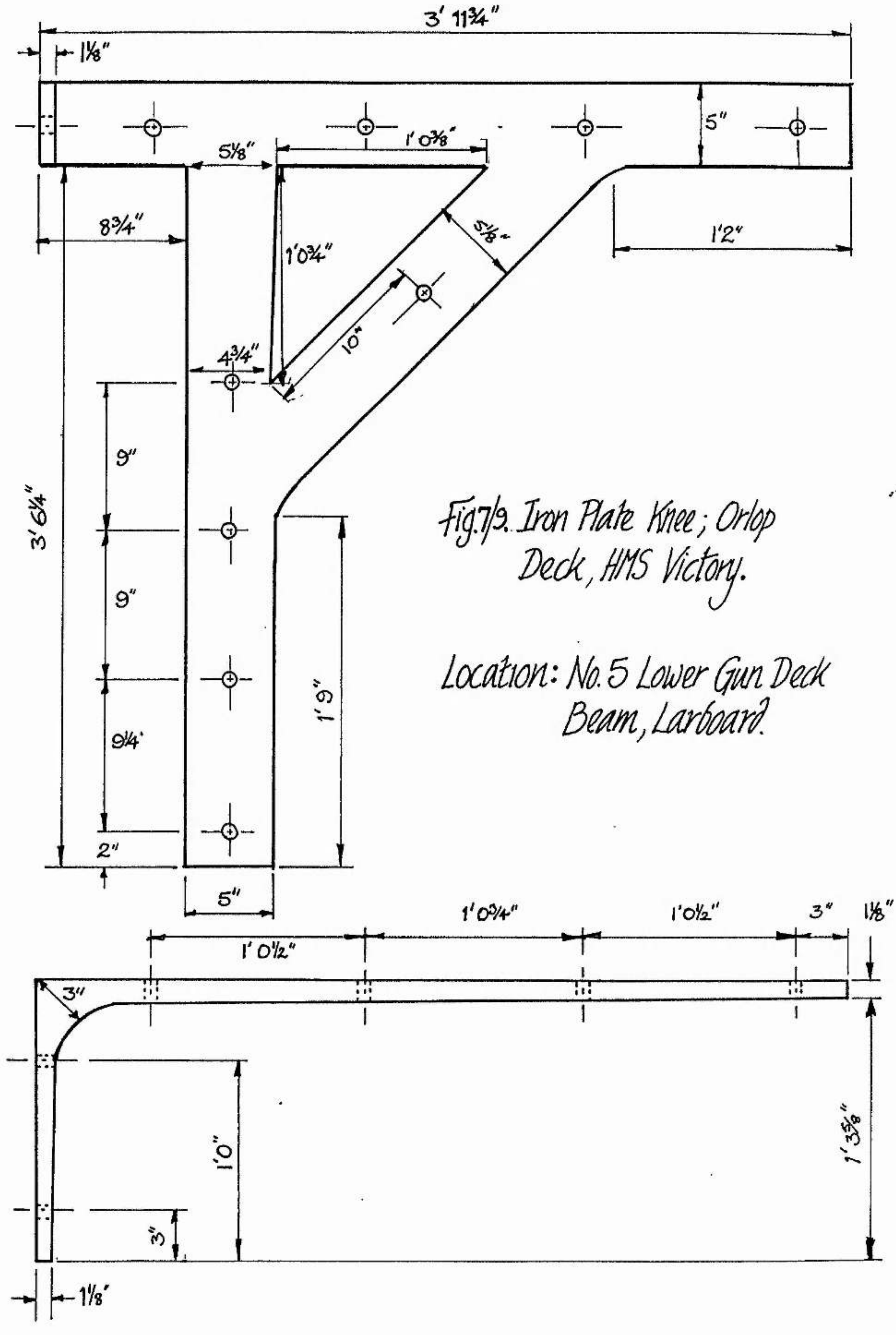


Fig.7/9. Iron Plate Knee; Orlop Deck, HMS Victory.

Location: No.5 Lower Gun Deck Beam, Larboard.

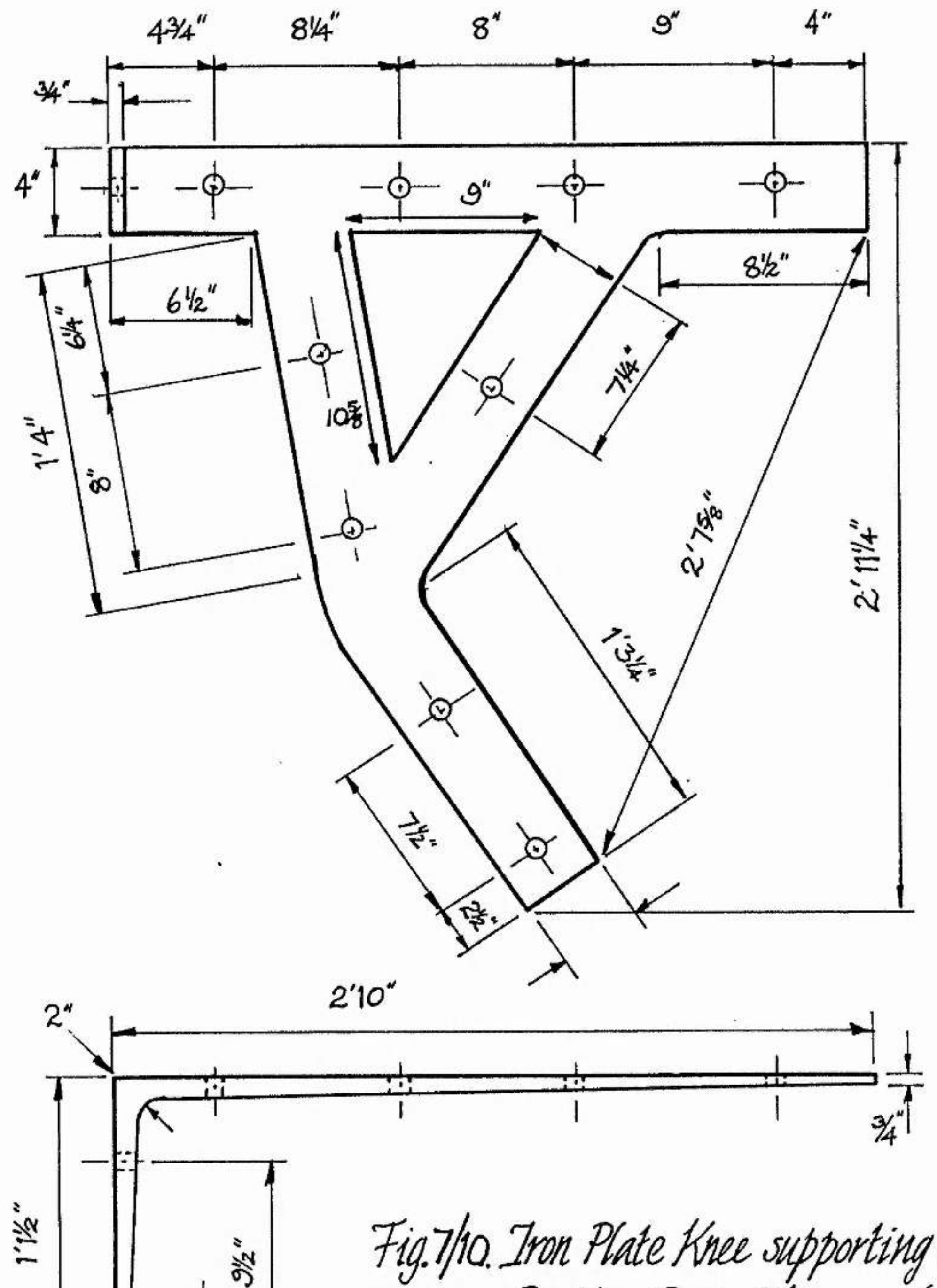
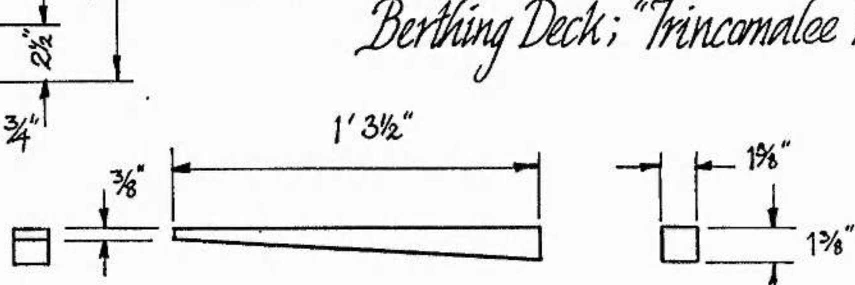


Fig. 7/10. Iron Plate Knee supporting the Berthing Deck; "Trincomalee 1817.



Iron Wedge; used opposed in pairs with Chock Knees.

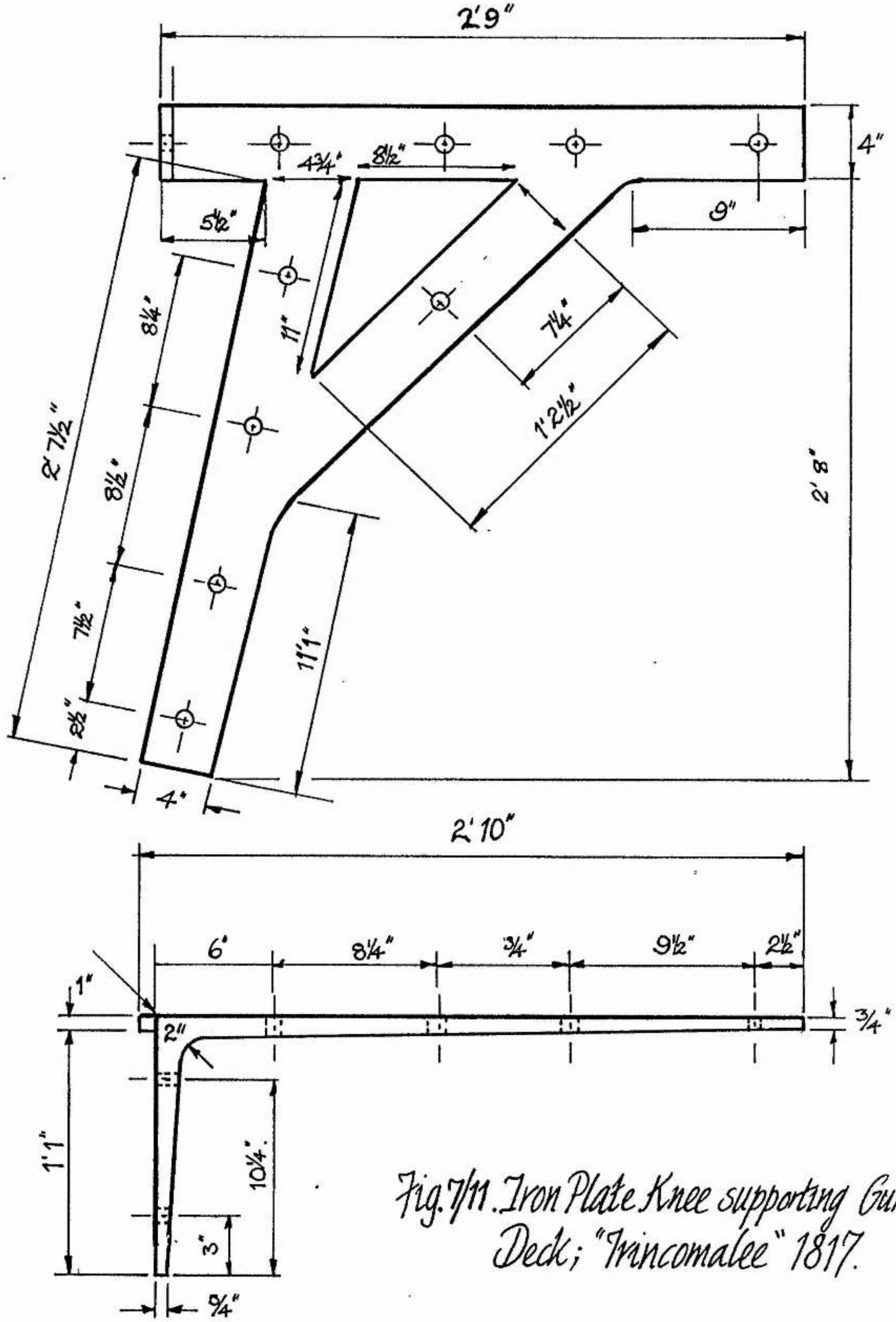


Fig.7/11. Iron Plate Knee supporting Gun Deck; "Trincomalee" 1817.

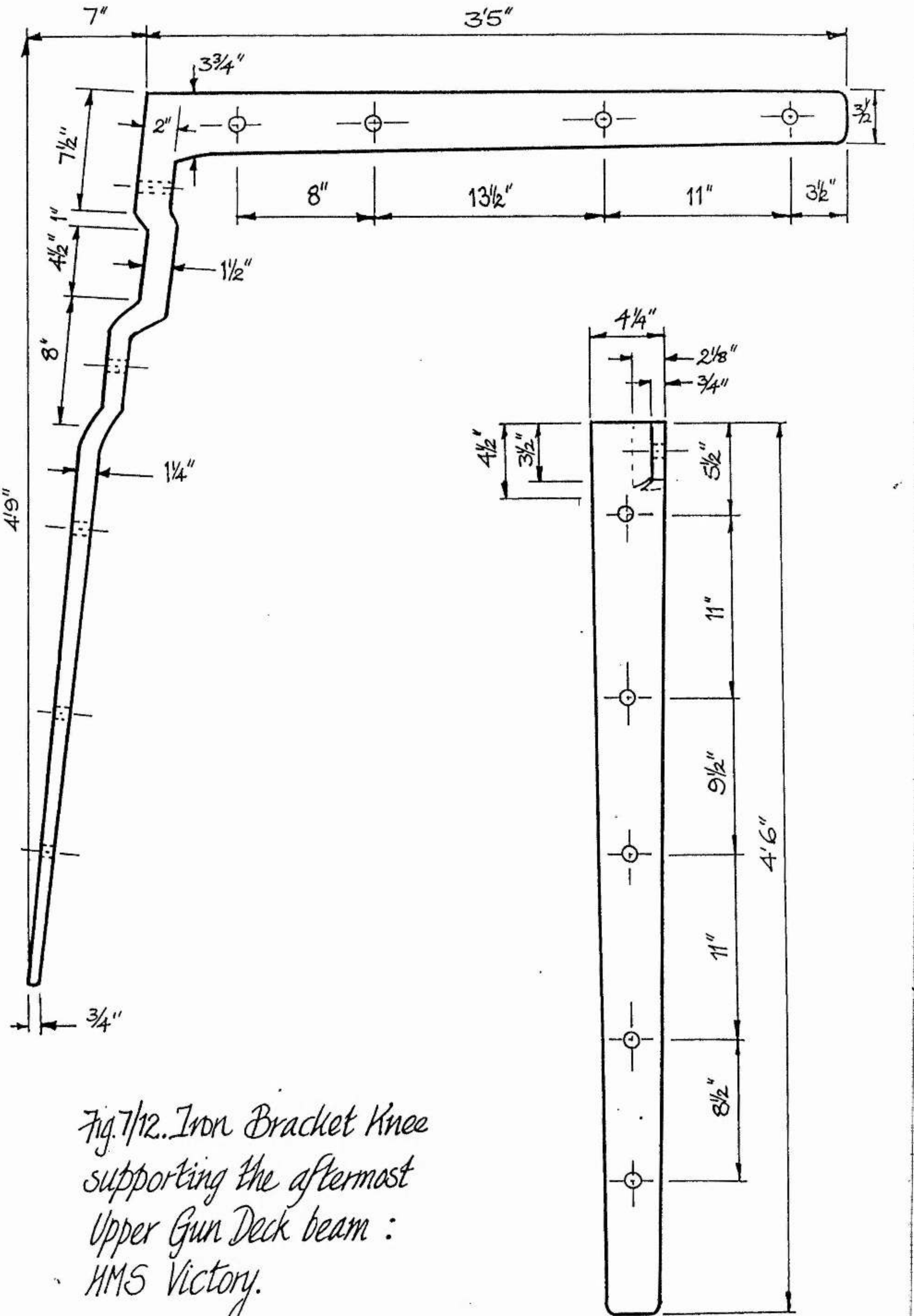


Fig. 7/12. Iron Bracket Knee supporting the aftermost Upper Gun Deck beam : HMS Victory.

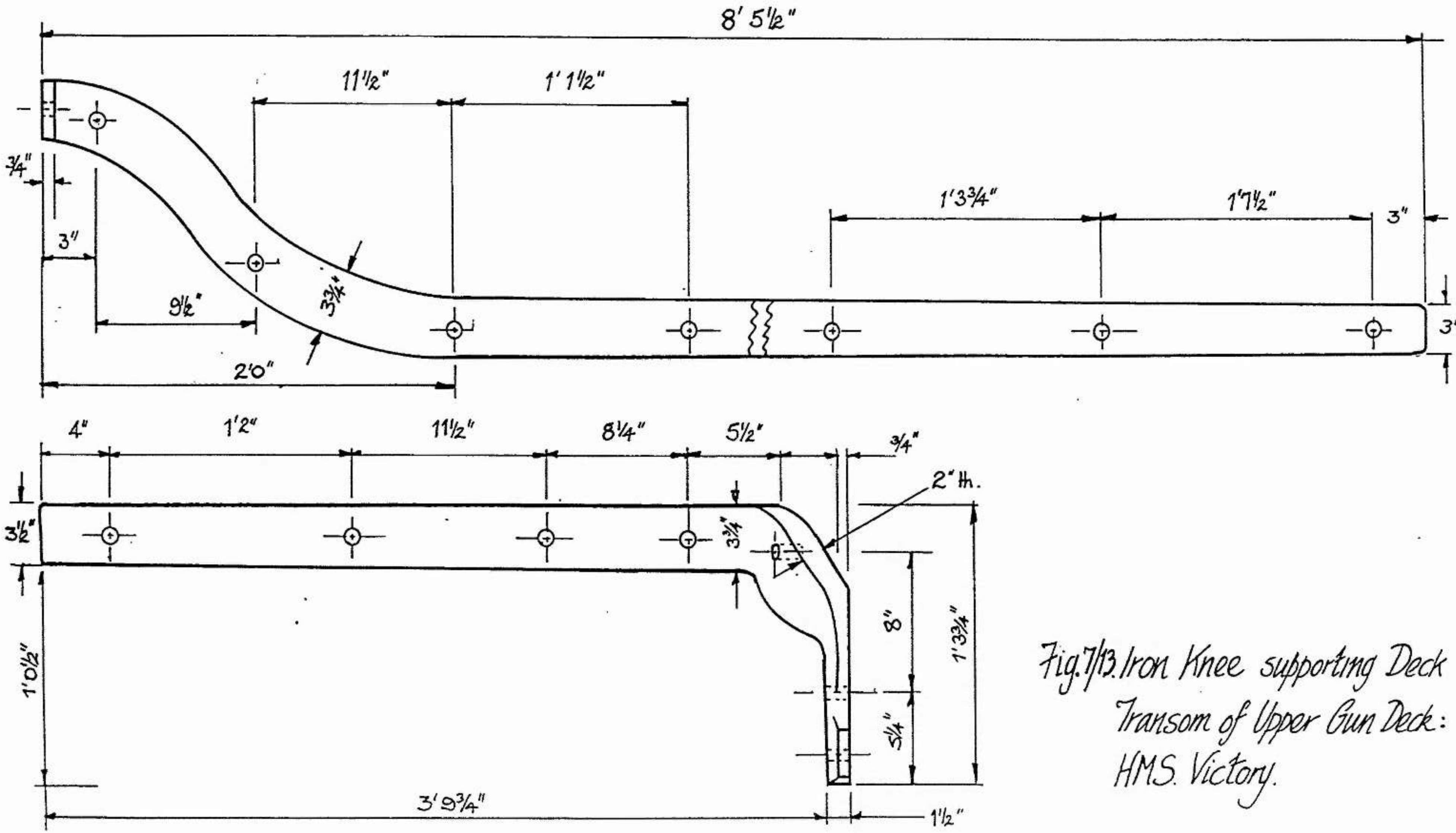


Fig. 7/13. Iron Knee supporting Deck Transom of Upper Gun Deck: HMS. Victory.

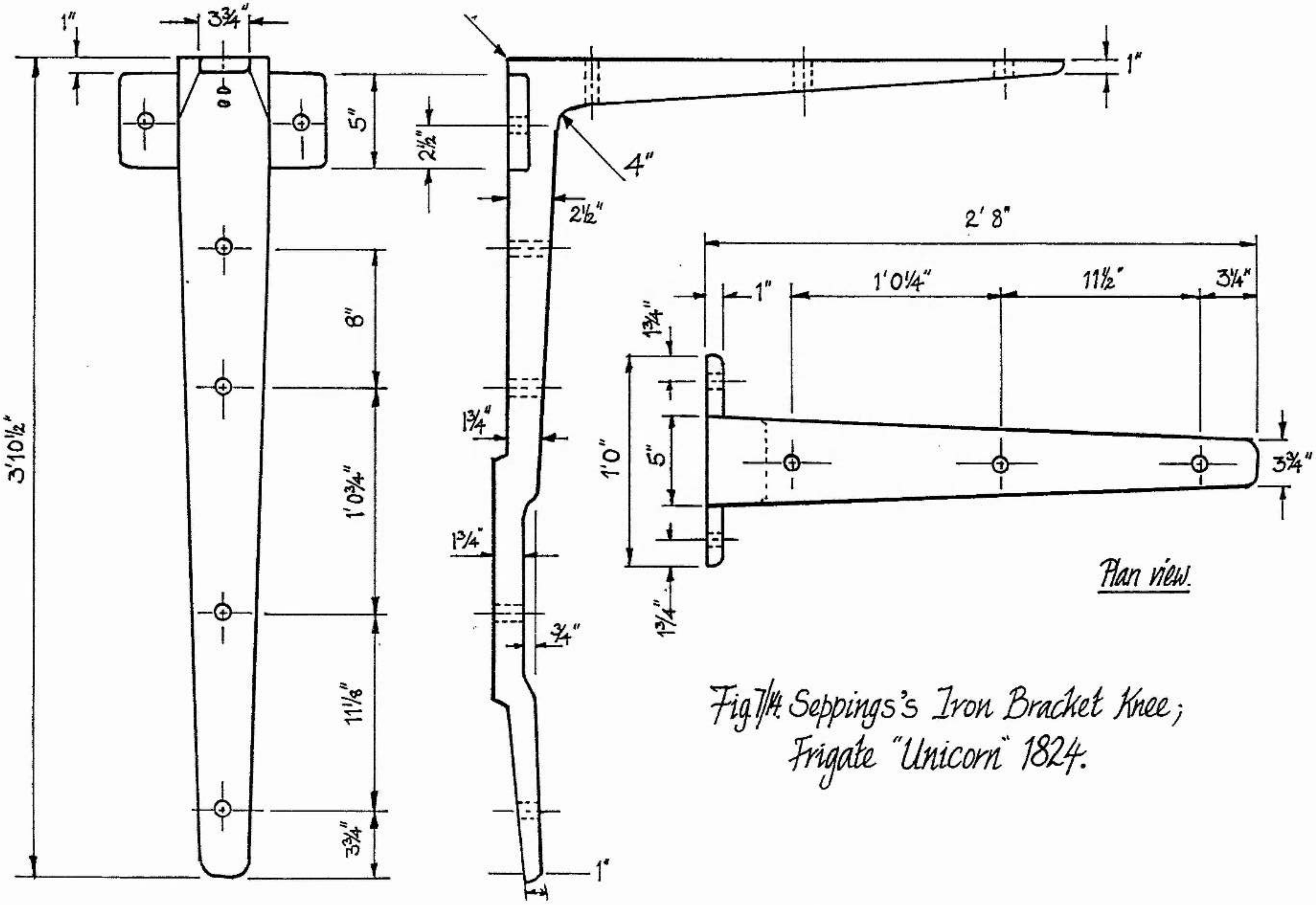


Fig 7/14 Seppings's Iron Bracket Knee;
Frigate "Unicorn" 1824.

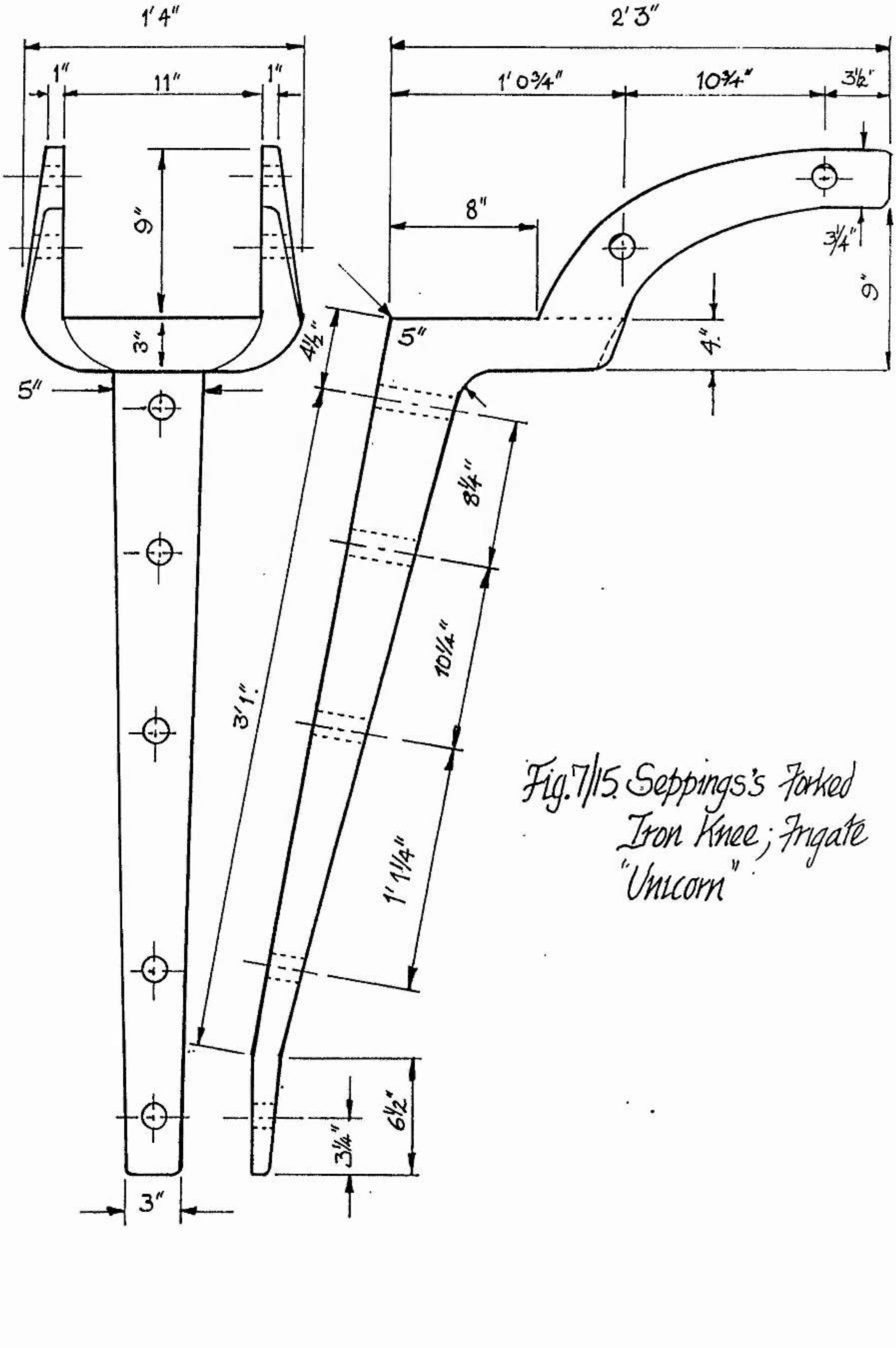


Fig. 7/15. Seppings's Forked Iron Knee; Frigate "Unicorn"

Fig. 7/17.

Fig. 1.

Plan of the Stern.

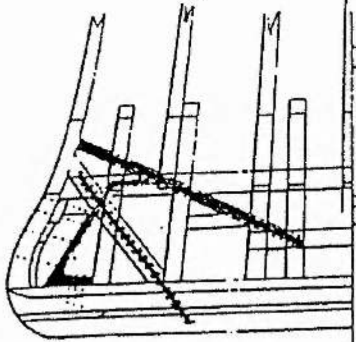


Fig. 2.

A Transverse Section.

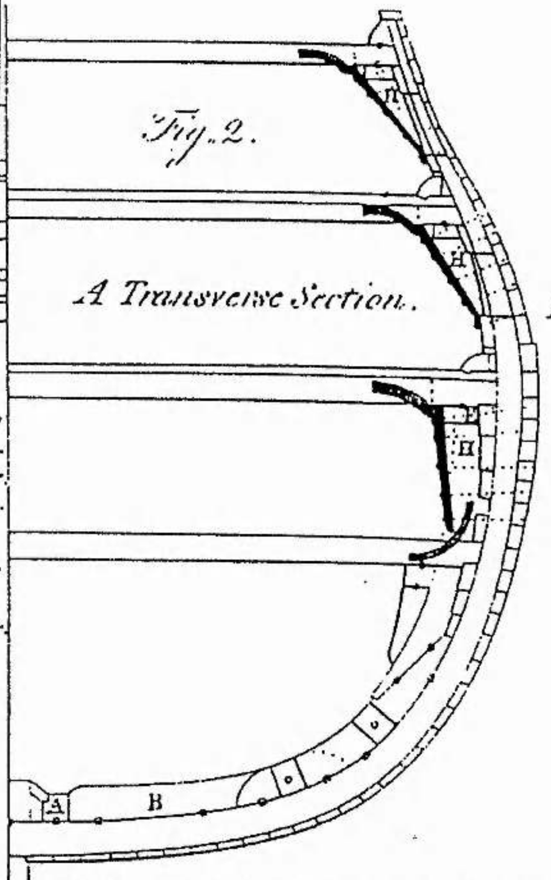
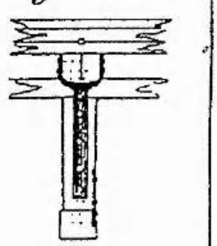


Fig. 3.

Plan of Iron Knee



References.

A.A. *Limber strake and additional Keelson, forming abutments for the lower part of diagonal frame.*
B.B. *Timbers of the diagonal frame.*
C *Longitudinal pieces to Ditto.*
D *Trusses to .... Ditto.*
E. *Internal hoop or Gundeck shelf piece forming abutment for the upper part of the diagonal frame.*
F. *Abutment pieces for Trusses between ports.*
G. *Trusses.*
H.H. *Chocks under Shelf piece for Iron Knees.*

Plan of the Breasthooks & Crutches.

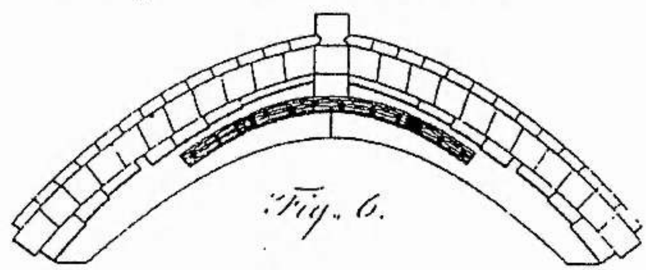


Fig. 6.

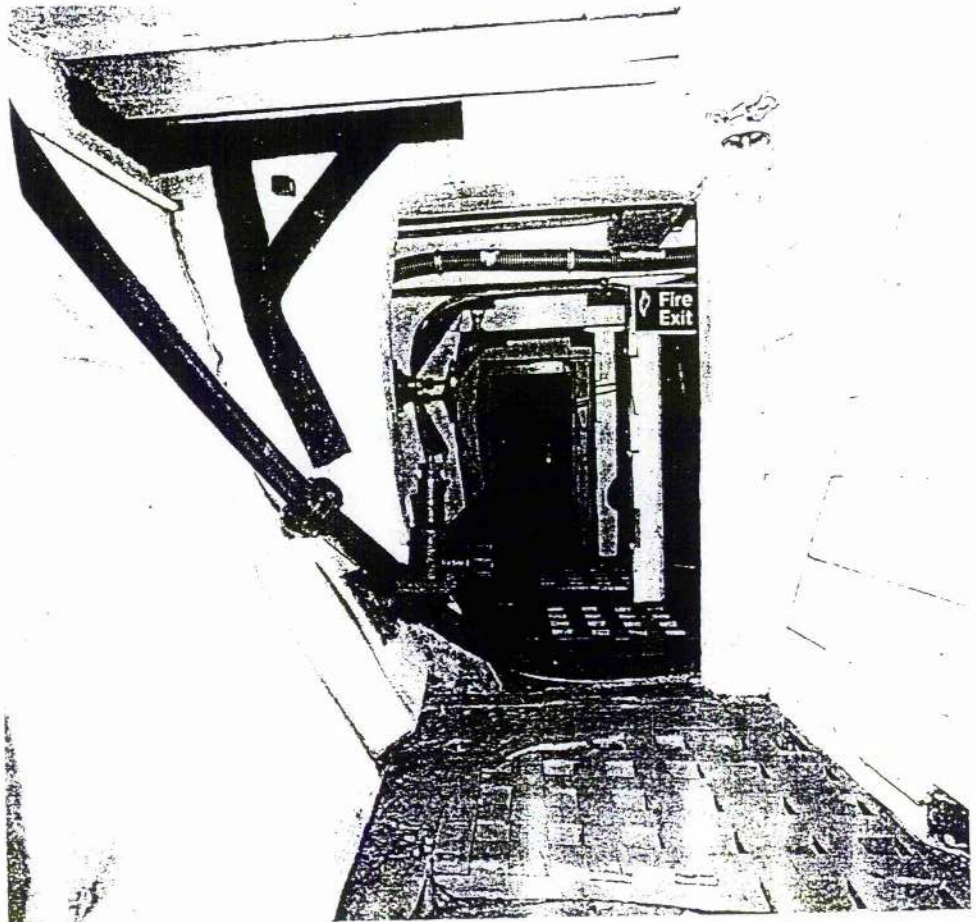


Fig.7/16.Carpenter's Walk on the *Foudroyant*, port side looking forward. The chock knees and respective plate knees are utilised throughout this deck. The modern valve set into a timber block occupies the same position as the original sea suction employed for washing down decks and firefighting. Note the upper faces of the lodging knees on the deck and the opposed iron wedges set into the heads of the chock knees.

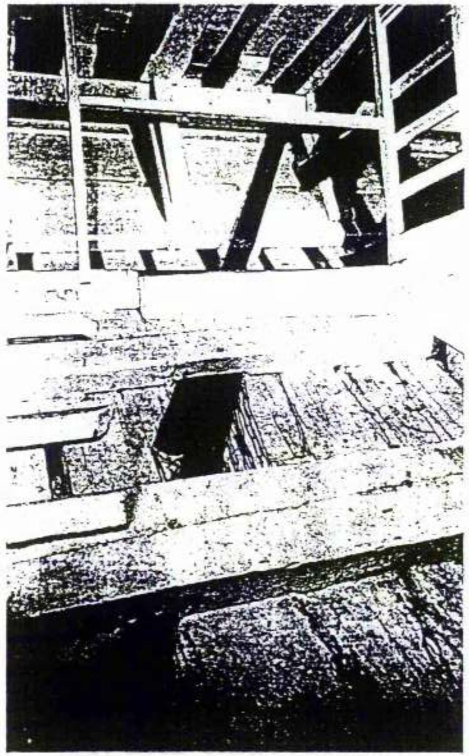


Fig.7/18.The gun frigate *Unicorn*. A Seppings diagonal iron rider plate fitted in two sections, each 6ins wide and 1in thick. This view shows its extent from the lower strake of thick stuff to the deck clamp of the berthing deck. The level of the fore platform in relation to the hold is level with the uppermost bilge step.

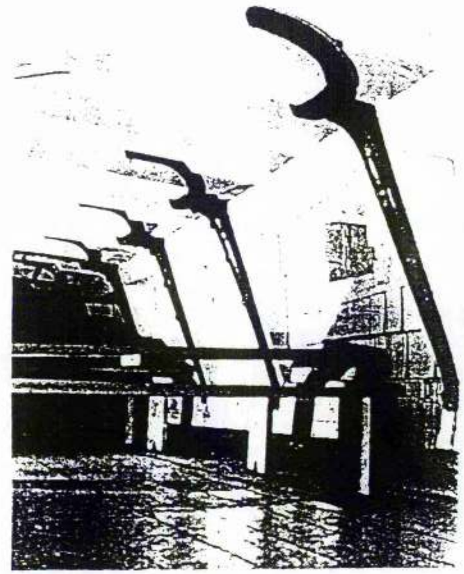


Fig.7/19.*Unicorn*. The port side of the berthing deck showing Seppings' forked iron knees and their associated chocks. This view also shows the beam shelf, deck clamp, lining and the spirketting. Note the packing pieces fitted under the beam ends of the intermediate beams. The rectangular hole cut in the ship's side is not original. This fore part of the berthing deck was the living quarters for the common sailor, the table slung from the beams with a long stool being typical of a 'mess' at that period.

Chapter 8.

Bow Construction.

Like all 1st, 2nd, and 3rd rate ships of the 18th century, the *Victory* was initially designed with a beakhead bulkhead constructed transversely across the fore end of the upper gun deck. This form of bow, which had fully developed during the Tudor period,[1] was to remain in vogue in most line of battle ships until the early part of the 19th century.

What we see on *Victory* today is in effect a replica of the beakhead form she retained until her bows were modified during her 'great repair' of 1814/16. The only difference however is that today there is a false beak deck built some 18 inches (45.72 cm) above the level of the upper gun deck [2] This nonconformity, fitted during restoration work carried out in the 1920s, was added in order to raise the level of the ship's head and sheer which had fallen due to extreme hogging. Hogging at the fore part of the ship was found to be about 18 inches (45.72 cm). The cause of this appears to lay in the fact that the *Victory* was riding on her moorings from 1816 to 1922, a period of 106 years, which was not what was expected of any wooden built ship.

During her 1920s restoration other measures were also undertaken to counteract the fallen sheer problem. Beside fitting a false deck, the forecastle also had to be raised in order to revert the ship to an acceptable external appearance. Here, additional beams were fitted over the originals to chock-up the deck. [3] This effectively raised the Forecastle some 8 inches (20.32 cm) at the fore end. During further restoration, carried out in the 1980s, both the original beams and the 'chocks' were removed, and the new beams being fitted in their room were actually raised up accordingly to retain the level of the deck. This, although still deviating from her 1765 construction, at least provided a somewhat more acceptable internal appearance. Obviously, clamps (beam shelves) and the lengths of hanging knees fitted in wake had to be adjusted to accommodate this alteration.

To reiterate, when first built, the beak deck was actually an extension of the upper gun deck. The beakhead bulkhead itself was, by comparison to the ship's bulwarks, rather lightly built. Construction comprised eight stanchions set with their heels tenoned into a collar beam set across the deck. The heads of these stanchions, which terminated above the flat of the forecastle forming a fife rail, were bolted to the fore face of both the cat beam and cat tail. Each stanchion was disposed such to form the sides of four access doors; two leading to the beak deck, and two to the roundhouses. There were also two chase ports. [4] Originally only the fore side of the bulkhead was planked up, this comprised short deals 1.1/2 inches (3.81 cm) thick let into rabbets cut into the stanchions.

As seen from the above description, structurally the beakhead bulkhead was defensively weak and highly vulnerable to raking fire from ahead. The fact that no structural alterations had been made to ship's bows for well over a century reflects the conservative attitude to how ships fought. The standard 'line of battle', where ships sailed in line head to stern firing broadside to broadside with the enemy, had not really changed since first introduced by Monck during the Dutch Wars and formerly authorised circa 1690. [5] Though well tried, and rigidly adhered to, strategically this tactic did not always permit officer's to get fully to grips with their opponents. Time taken to form a squadron, or squadrons, in line ahead, and simultaneously to gain the weather gauge, was often impeded due to wind conditions with the result that the advantage sought was often lost. Towards the latter part of the 18th century, much to the credit of the amateur tactician John Clerk of Eldin, [6] current battle tactics employed were being analysed and modified to form the strategy of 'breaking the line' or 'crossing the T'. This manoeuvre, first adopted to some degree by Rodney at the Battle of the Saintes 1782, and later by Howe in 1794, was eventually to culminate in the brilliant tactics used by Nelson at Trafalgar. These revised tactics released captains of ships from the restrictions imposed by Article 20 of the Admiralty instructions. [7]

It was only then, now that ships could expose their heads and sterns to the enemy, that the weak structure of the beakhead bulkhead became apparent and that ship design needed to be reviewed. The concept of constructing ships with a full round bow was not new: Frigates had been so built since circa 1760, and smaller vessels some 30 years earlier. round bows had long been common in merchant ships including, due to

Snodgrass, those of the East India Company. The round bow had also been used on foreign men-of-war before its adoption by the British navy. [8] One example was the Venetian 64 gun ship *Vulcano* captured by the French in 1797 and renamed *Causse*. This ship was later captured by the British at Alexandria in 1800. [9] The fact that the beakhead bulkhead was a liability in battle is a factor that was later very much emphasised when Seppings submitted his letter to Lord Melville concerning the principle of introducing circular sterns, to quote; [10]

Navy Office. 1st January, 1822.

My Lord,

............other. It may be right to remark here, when speaking of circular bows, that previous to their introduction, the upper decks were exposed, and liable to be raked: and, as a instance, I beg to state, that after the battle of Trafalgar, the Victory was repaired at Chatham, in which yard I was then Master-Shipwright. It struck me forcibly, how much she had suffered on the upper or main deck, through the beakhead, when bearing down on the enemy at the commencement of memorable action, arising from the want of continuing the circular bow with regular timbering, &c., from the upper, or main deck, above the forecastle, as is now practiced; and it was perfectly evident that had this ship be so formed , many a life would have been saved, as no shot of any description appeared to have entered the lower or middle decks, where the bow was regularly and solidly built.; whereas, on the contrary, the common grape shot had raked her through the slight bulkhead., at the fore part of the main or upper deck, where her bow was so built. All this was fully acknowledged by Sir Thomas Hardy, her then Captain; in consequence if which, I came to the determination to recommend that ships of the line should, in the future, be built with circular bows, and referred to a ship so treated (Namur) at my recommendation, some little time before; but I did not succeed in establishing this principle, until the naval administration of the Right Honourable Charles Yorke. [11]

The *Namur*, referred to in Seppings' letter, was initially a 2nd rate of 90 guns launched in 1756 designed by Bately to the amended 1745 Establishment. [12] The letter infers that this vessel was the first purpose built warship furnished with a Round Bow, this was not exactly true. On the 29th January 1802, with recommendation from Seppings, the Admiralty proposed to the Navy Board to *"take off the Namur's upper deck as was lately done with the Blenheim".*[13] The 90 gun *Blenheim*, designed by Slade, was launched at Woolwich 5th July 1761. Like all 90s built at that period she was reclassed in 1778 as a 98 with the addition of 8 guns on her quarter deck. [14] The fact that the *Blenheim* was converted to have a round bow during her refit between October 1798 and May 1801 is verified from the Progress Book. [15] Consequently the *Namur* was cut down and modified to a 74 with a round bow. This was implemented in 1804. [16] Modification was simply made by removing the entire upper gun deck, and consequently, the beakhead bulkhead. The fore part of the middle gun deck, which was already built full, effectively became the built-up round bow. All was still experimental at this stage. After inspecting the *Victory* in 1806 Seppings already saw the advantages of constructing ships with this form of bow therefore on the 28 May 1807 he submitted his proposal to the Navy Board that all ships should be constructed with round bows. [17] Finally, after four years, the Admiralty abolished the beakhead bulkhead and authorised the introduction of the round bow to all ships of the line. This was implemented by Admiralty Order dated 29th May 1811. [18] Not only was this implemented on ships constructed in home dockyards but also abroad. Copies of the draught of the *Conquestadore* were sent to Bombay as a guide for building the *Cornwallis,* launched May 1813, and the *Wellesley,* two years later. The *Benbow,* building at Chatham 1813, was also fitted accordingly. [19] The *Victory,* which discontinued active service at the end of 1812, pending she was to be retained, would in turn be so fitted.

In March 1814 the *Victory* commenced a large rebuild at Portsmouth during which her beakhead bulkhead was removed and a round bow constructed in its stead. [20] How this was actually implemented is now lost forever as, in the haste of reconstructing the ship to her Trafalgar configuration with a beakhead bulkhead, little archaeological survey work was undertaken. Frame timbers forming her round bow were simply removed or shortened accordingly to produce the desired effect. If there was any further evidence, then this too has been lost as her entire bow section was again rebuilt during the 1980s.

With exception to old photographs, extant plans, [21] and the Dockyard lines [22] taken off before her bows were reconstructed in the 1920s, the manner in which she was physically constructed with a round bow can only be theoretically ascertained. In view of this fact it can be assumed that when being rebuilt in 1814/16, all cant frames and hawse pieces would have been cut back to form suitable scarphs. These timbers were then lengthened by adding new pieces that extended to the height of the forecastle. All appropriate capping pieces, rails, etc. were then installed. All upper gun deck ship's side planking: spirketting, lining, and beam shelves; were then extended forward to the bow. Extra beams with their relevant knees were then fitted to support the now lengthened forecastle. Externally, planking strakes and rails, etc. were continued around to the bow in the normal manner. With exception to a few minor fittings; i.e. boarding fitted across the head rail to provide more modesty for the ship's heads (toilets) little changed over the proceeding years until the Victory was reconstructed with her Trafalgar style beakhead bulkhead in the 1920s.

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21. *Plan of the Victory's Upper Deck.* Portsmouth Yard: Dated June 17th 1830. (Dockyard copy of original drawing).
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Chapter 9.

The Orlop Deck.

The root of the word orlop is Germanic relating to a temporary surface, 'to overloop the hold' with planks. In all probability boards would have been laid over the 'tuns' carried in medieval Cogs forming a false deck for other stores or to provide living space. In naval vessels the term orlop originally related to the lower gun deck This fact is verified from various sources: An early treatise c. 1620-25 states that, *'The Orlop, which is the first deck above the hold, is chiefly for the use of ordnance: upon which there are divers ports cut through the ships side to place them in. The fore part thereof is called the fore pyeke (sic. peak) and in ships that have low hawses a part thereof called the manger.... '* [1] Sir Walter Raleigh also wrote, "*...we carry our ordnance better than we were wont, because our nether-overloops are raised commonly from the water,.... We have also raised our second decks and given more vent thereby to our ordnance, tying in our nether-overloope".* [2] Here Raleigh refers to the after part of the gun deck which was once stepped at a different level, a fact that is further clarified later by Carr Laughton's article on Tudor guns. [3] By 1765 the concept of the orlop had altered and had become firmly established as ' *a temporary deck below the lower [gun] deck of large ships for the conveniency of stowing away cable.* [4]

When first built the orlop in the *Victory* did not extend the full length of the ship as it does today. In all seven extra beams have been fitted in addition to the original twenty specified. For 1st Rate ships Steel states the following specifications; [5]

To have beams in number..20.
Aftside of the after beam afore the after perpendicular........................25 ft.
Fore-side of the foremost beam abaft the foremost perpendicular..........10 ft.

From the above criteria, together with extant draughts, it is clearly indicated that deck planking did not extend beyond the foremost beam or abaft the breadroom bulkhead. In effect, the breadroom utilised the entire aftermost space from the underside of the gun deck to the ceiling of the hold. Three beams have since been added abaft No.20 beam purely for utilising space.

The fact that the orlop was 'a temporary deck' is of vital importance: First, this deck did not extend the full length of the ship: Second, with exception to the two fixed platforms, one afore and one abaft, the main portion of this deck was very lightly constructed. Planking between the two platforms comprised short thin boards of about 1.1/2 inches (3.80 cm) thick set between the beams. To permit this the top edges of the beams were themselves rabbetted 1.1/2 x 1.1/2 inches (3.80 x 3.80 cm) to receive the ends of the short planks aforesaid. Again this fact is clarified by Steel; [6]

Plank or Board for the Orlop flat, thick..2 ins.
And let on to rabbets taken out of those beams, and those carlings which are even with the upper sides of the beams.

The thickness of planking quoted above relates to the normal short boards and not the plank used for the platforms.

Close inspection of orlop deck plans show the rabbet lines on deck beams between the established platforms, those disposed at the platform extremities being rabbetted on one side only. . Steel clearly states; " *but in the midships, from the fore part of the spirit room, to the after part of the fore magazine, the beams are laid level with the surface of the deck, and the planks rabbitted (sic) in from one beam to another.* [7]

Recent survey has shown that the carlings (with exception to the side tier) and ledges wrought throughout this section were also set down 1.1/2 inches (3.80 cm) below the upper surfaces of the beams. Investigation also revealed that the short planks laid over carlings were reduced in width in order to form a land on the carling to receive the edges of adjacent planks. **(Fig. 9/1)** On *Victory*, these particular boards were found to be 6 inches (15.24 cm) wide whereas the other planks varied between 8 (20.32 cm) and 12 inches (30.48 cm) in width. [8]

All of the particular features aforesaid are clearly shown on the model of the *Royal George* (1756) currently displayed in the National Maritime Museum. [9] Inspection of this model indicated the following points;

a. The after side of No.1 beam and fore side of No. 2 beam are rabbeted to receive thin boards.
b. Rabbets are omitted between the after side of No. 2 beam and fore side of No. 6 beam.
c. Rabbets are omitted from the after face of No. 16 beam to No. 20 beam, the aftermost beam of the orlop.
d. All beams set in the rooms between the after side of No. 6 beam and fore face of No. 16 beam are rabetted on both sides to receive thin boards.
e. The side tier of carlings were fitted level with the beams.

The advantages of adopting this form of construction technique were as follows;

a. The upper face of the planking was level with the upper surface of the beams. Though very marginal, this effectively increased headroom.
b. Light construction minimised weight.
c. Use of short planks reduced timber wastage.

Originally, these boards were never fastened down and could be removed. Likewise respective carlings and ledges fitted between the beams could also be unshipped. Carlings wrought in wake between the fore and after platforms were found to be 1.1/2 inches (3.80 cm) less in depth than those fitted afore and abaft, **(Fig. 9/2.)** the difference accounting for the thickness of the thin boards. In effect, it was only the orlop beams and fixed platforms which formed an integral part of the ship's structure. The facility of having portable boards, carlings, and ledges, was provided for the following reasons;

a. To attain access, where convenient, to the hold below. (Refer Note 1 below).
b. To allow the wet anchor cables to drain into the hold.
c. To extend storage of casks, etc. beyond the limit of the hold. (Refer Note 2 below).

Of note, it proved far more convenient, especially when water casks needed refilling, to embark or remove stores by a direct vertical route rather than manipulating heavy casks fore or aft to either the main or fore hatchways. On another point, the specification 'Depth in Hold', which is always written on a ship's draught, was always a measurement taken from the underside of the gun deck planking to the upper surface of the 'Stake next the Limbers'. This dimension totally excludes the fact that there was an orlop deck fitted between the two points measured.

As previously stated there were also two fixed platforms. These were initially constructed with 2.1/2 inch (6.35 cm) planks laid on top of the beams in the conventional manner. Furthermore the edges of these boards were cyphered or rabbeted together and caulked forming a hermetic seal to the compartments below. Where platform planking terminated, the boards were sealed with a transverse fillet. This fillet, which was usually of quarter radius cross section, prevented water ingress into the end grain of planks.

The primary function of the fore platform was to provide a protective shield over the grand magazine and its adjacent light room below. It appears from one existing *Victory* draught that the fore platform extended from No.2 to No.5 beam. This does not appear to comply with the standard practice clearly defined on the *Royal George* model as stated above, i.e. No.2 to No.6 beam. It also does not comply with other contemporary works which state that the platform extended from "forward to beam number six".[10] Irrespective of period the aftermost transverse bulkhead of the grand magazine on *Victory* was always fitted at No. 6 beam. The reasons why the platform was drawn terminating at No. 5 Beam **(Fig.9/2)** remains unresolved and in all probability could simply be a drawing error.. Alternatively, it is possible that the after bulkhead of the grand magazine could have been fitted at No. 5 beam when *Victory* was first built (1765) and repositioned later when the magazine was extended aft to terminate at No.6 beam. Unfortunately no original 'as built' draught exists to verify this point. If a modification was made then it was probably introduced in the repair of 1783 when the after powder magazine was removed and two hanging magazines were installed in its room. With the absence of an after powder magazine, the capacity of the grand magazine may have been increased to provide additional space to store more gunpowder barrels.

Irrespective, firm evidence supports the fact that the fore platform of all 1st, 2nd, and 3rd rate ships extended between beams No. 2 and 6, or more specifically, to the beam that supported the after riding bitts.

The after platform **(Fig. 9/3)** was also laid with 3 inch (7.62 cm) plank which again was cyphered and caulked for similar reasons. On initial build, this platform extended from No. 15 beam adjacent the aftermost bulkhead of the main hold and terminated at No. 20 beam. To reiterate, there was no deck laid aft beyond this point. The function of the after platform was to protect the after powder magazine and the spirit room each of which held potentially hazardous materials. Further details of standard construction are to be found on many contemporary draughts. [11]

Of singular note, recent survey has revealed that lodging knees wrought in wake of platforms were set down 1.1/2 inches (3.81 cm) below the upper edge of their respective beams. [12] This fact applies to the platforms only and does not correspond to the normal practice of fitting lodging knees level with the top of a beam as found throughout the remainder of the orlop deck. This also applies to lodging knees fitted in wake where the after platform has been extended to new No.16 beam.

It was also discovered that within the confines of the platforms, corresponding ledges wrought between the outer tier of carlings and lodging knees at the ship's side remained fitted level with the beams. In some cases, these ledges extended to the ship's side and were fashioned accordingly to lay over the lodging knees. It appears that the space produced above the lodging knee permitted better ventilation.

In theory every lodging knee fitted throughout the ship should be fitted in this manner with exception to those fitted in the midship section of the orlop. This opinion is based on evidence found that other knees, currently considered as fitted in the conventional way, were found to have rotted within the enclosed parts of the knee; i.e. the upper and outboard surfaces. The only evidence regarding the air spaces can be found in the *Shipbuilder's Repository.* [13] However, at present, this fact is not proof enough for should this have been the case then all lodging knees would have been fitted in the *Victory* with spaces accordingly.

Changes in orlop construction were introduced circa 1808. This relates to the lengthening of the platforms. Evidence supporting this fact is taken from two draughts: The *Caledonia,* [14] **(Fig. 9/4)** launched 25th June 1808 and *Hibernia,* **(Fig. 9/5)** as modified in 1821. [15] With respect to the former, the fore platform had been lengthened in two directions, forward to No. 1 beam, and aft to No. 9 beam located at the fore side of the fore hatchway leading to the hold. (Refer drawing: Appendix III). The modification implemented to the *Hibernia* involved fitting an extra beam forward and extending the 3 inch (7.62 cm) planking in both directions, the after part terminating at the fore hatchway. As before a transverse fillet was fitted to prevent water ingress to end grain. This alteration appears to have been introduced for the following reasons;

a. To extend the protective area covering the grand magazine with its integral filling room and adjacent light room.

b. To provide greater security to the three storerooms fitted between the grand magazine and the hold. These rooms were: larboard - Boatswain's store; starboard - Carpenter's store; and centreline - a coal hole. Evidence suggests that the deck of each of these storerooms were laid with loose fitted planks. Below these rooms was a shot locker.

c. To provide a greater fixed deck area to comply with recent modifications to Fore Platform compartment layout.

This modification was adopted to the *Victory* during her 'great repair' carried out in Portsmouth between 1814 and 1816. **(Fig. 9/6)** Recent survey undertaken during restoration of the foremost orlop beams disclosed some interesting points regarding the construction of the fore platform. The main planking, which extended aft to No. 8 beam (originally No. 7 beam) comprised boards 10.1/2 inches (26.67 cm) broad and 3 inches (7.62 cm) thick. All were found to be rabbeted 1.1/2 inches (38 mm) along their edges, the seams being caulked in the standard manner. Caulking material used was 1/8 inch (3.18 mm) thick. All planks were fastened with iron spikes. Overlaying these planks was a cladding of thin deal boards 9 inches (22.86 cm) broad, varying between 1/2 and 5/8 inch (12.7 and 15.88 mm) thick. **(Figs. 9/6 & 9/7)** All were laid fore and aft directly over the seams of the main planking underneath and secured with plain round sectioned nails. No evidence of caulking was found.[16]

Fitted to the underside of the main planking was a second cladding **(Fig. 9/7)** comprising short deals wrought in the athwartships direction. Each were fitted, as convenient, between respective beams, carlings and ledges. These boards varied in thickness, some being 1.1/2 inches (38 mm), others 3/4 inch (19 mm). Those boards 3/4 inch thick were doubled to form the desired thickness of 1.1/2 inches (38 mm) as dictated by adjacent locations. Whichever the case all were loose fitted and retained with deal battens 3/4 inches (19 mm) wide and 1 inch (25.4 mm) deep nailed to either the adjacent beam, carling or ledge as required. Of particular note, these boards only extended fore and aft between No. 3 and No. 6 beam, and transversely between the outer of carlings, the reasons for which are explained further. Furthermore, to reiterate an aforesaid point concerning the lodging knees and outer tier of ledges, their disposition at this location was found to differ from standard construction practice.[17]

Obviously the entire construction, the two layers of cladding, lower set lodging knees, and the outer tier of ledges raises considerable question. By comparison to other existing historic ships, *Trincomalee* (1817) and *Unicorn* (1824), the manner in which the platform on the *Victory* was laid is somewhat more complex. Furthermore, it appears that additional beams were fitted during the 1814-16 refit. Beam No. 1 was replaced with a timber of greater scantling, and a new beam was fitted in the room between No. 6 and original No. 7 beam. As result No. 7 beam, which originally formed the fore boundary of the fore hatchway leading to the hold, effectively became No. 8 beam. Of cautionary note, the new No. 7 beam could have been fitted during the 1800-03 repair and modified later in 1814-16. This point complies with other contemporary draughts circa 1798. [18]

My hypothesis are that extra beams were fitted to provide greater strength to a now aging ship also their addition complied with the then current building specifications. Original practice indicates that beams in wake of the platforms were often laid at a lower level than the those fitted amidships. This was done to compensate for the thicker planking laid on the platforms thereby effecting a constant level surface throughout the orlop. An earlier draught of *Victory*, assumed to be dated after her repair in 1783, clarifies this fact. This specification is also stated in Steel's *Naval Architecture*; [19]

Orlop Beams: *The upper sides to be below the………Afore ………7 ft 3 ins.* (2.20 m).
under side of the gun-deck plank…… Midships……7 ft 1 in. (2.16 m).
at the middle of the beam …………… Abaft ……… 7 ft 3 ins. (2.20 m).

The difference in depth of 2 inches (5.08 cm) closely corresponds to the existing 1.1/2 inches (3.81 cm) variation found between beams and lodging knees currently fitted on *Victory*. This fact implies that the beam height was altered during her 1800-03 refit, if not earlier, and that the lodging knees were retained in their original positions to reduce work. This point also accounts why the ledges were fitted over the lodging knees. Why design changed is obscure; however in all probability this modification was introduced to simplify construction.

With regard to the aforementioned deal cladding fitted under the platform between No. 3 and 6 beam, this appears to be an accepted precautionary measure fitted to prevent ingress of damp in to the grand magazine only. For similar reasons, cladding was also found fitted to the underside of the lower gun deck planking in wake of the Carpenter's and Boatswain's cabins on the orlop.

The thin cladding boards laid over the platform planking were fitted much later for a very different purpose. When removed during subsequent restoration deposits of sand and grit were discovered laying under the boards. Photographic evidence circa 1905 [20] clearly indicates that the entire fore platform was devoid of any compartments whatsoever, these being installed after 1923. This point is validated from existing drawings. [21] Furthermore, there is no visual evidence provided on the underside of the lower gun deck beams to confirm that these compartments were ever rebuilt during the 'great repair' of 1814-16; there was no requirement as the ship was to be temporarily placed in 'ordinary'. 'Rase' marks inscribed into the aforesaid beams clarify they were fitted c.1814/15. Also, the photograph supplies no visual indication that the upper surface of the platform was originally clad. At that particular time, the entire area was utilised for the stowage of chain cables which themselves carried sand into the ship hence the residue found. In view that the thin boarding did not extend over the entire platform but only in wake of the storerooms, etc. reconstructed in the 1920s, their function was entirely cosmetic to level a somewhat worn deck surface.

The after platform had also undergone various modifications during *Victory's* career. 'As built' in 1765 the platform extended between original beam Nos. 15 and 20. This platform was later extended forward to terminate at the original beam No 14. (new beam No. 16). For additional support to the platform two more beams were added in the room between new beams No. 16 and 20. The planking of the extension was wrought in the conventional manner. Transverse under cladding 1.1/2 inches (3.80 cm) thick was only to found wrought in wake of the original after platform and not laid up below the extended section. Of importance, this fact indicates that this unwritten feature, whether fitted afore or abaft, was standard practice when the *Victory* was <u>first</u> built. The deck area between the transverse bulkhead defining the Surgeon's dispensary and breadroom, and the fore side of the spirit room hatchway has been sheathed with a thin cladding of deal boards 1 inch (2.54 cm) thick. Like that fitted on the fore platform, this appears to have been added to level the surface. Proof that this is not original lays with the fact that it does not extend abaft the transverse bulkhead, nor does it extend outboard within the cabins and storerooms either side of the ship.

Returning to the midship section of the orlop, today all of the short length boards wrought between the beams are secured firmly with nails. The fact that they are currently fixed is not for modern convenience but an evolutionary step in ship construction. To reiterate, these boards were once portable and, together with respective carlings and ledges, could be removed to attain easier access to the hold especially when watering ship. Water puncheons, which held either 150 or 184 gallons (681.9 or 836.46 litres) and weighing between 2/3 and 3/4 of a ton (0.68 and 0.77 tonne), were extremely cumbersome and time consuming items to load.

In 1814, a breakthrough was made to alleviate this task. Experiments of using iron water tanks in place of wooden casks had proved successful. This innovation also proved valid for other reasons. "*The use of iron tanks has preserved the purity of water, and the discontinuance of shingle ballast removed the unpleasant effluvia, that frequently arose from animal and vegetable substances in a state of composition, which were sometimes lodged therein; or other putrescent matter absorbed.*" [22]

These tanks, manufactured from wrought iron sheet, were made in cubical form about 4 feet (1.22 m) square. In capacity they contained approximately 400 gallons (1815 litres) of water. Obviously there was initial prejudice against their use in the belief that health could be impaired due to oxides of iron being able to *"enter the water by solution."* [23] This was far from true as investigations revealed that water contained within such a tank for a period of 5 years remained in a good state. This examination included a chemical test using *'tincture of galls'* [24] to detect presence of iron in water. No iron could be detected.

Here we see a positive result relating from the recent improvements of iron manufacturing techniques (refer Chapter 7) and the industry as a whole. More importantly, contrary to current thought, the introduction of iron water tanks bears considerable weight to alterations in ship construction especially with respect to the orlop deck. The advantages gained were many;

a. The task of removing/reloading heavy water casks was eliminated.
b. With respect to 'a' above, there was now no further requirement to construct the Orlop with portable planking, etc.

c. Water could be embarked by pumping from lighters direct to the tanks within the hold. Likewise water could be easily transferred by pump for domestic use.
d. Water tanks eradicated the use of shingle ballast, thus the trim of a ship could now be altered by simply transferring water from one tank to another.
e. The absence of shingle provided a healthier environment.
f. Water capacity was increased thereby improving operation time at sea.
g. Less water wastage caused by leaky casks.
h. Less chance of water contamination.

In consequence to their introduction, two changes occurred: Both platforms were extended towards the midship area; the thin loose planking laid at the midship section became fixed down with nails. Both these transitional features are evident on the *Victory*. The former relates to the extension of after platform fitted between No. 20 to No. 16 beam (current beam numbers) which subsequently closes over the after hold. When the after platform was extended, two additional beams were also fitted to provide better support; one abaft original No. 13 beam, and one abaft original beam No. 14. The centre portion of the latter stated beam has since been cut away in order to reconstruct the after hanging magazine, firm proof that it was fitted after 1805. The fore platform, as previously stated, had been extended aft to in the fore hatchway. With regard to the thin boards, all, with exception to those found under the after part of the fore platform constructed c.1814/16, are firmly fixed down.

Though not always apparent another influence that changed construction was the introduction of iron chain cable. Although iron cable had long been in existence it was both unreliable in strength and expensive to make. This soon altered with the then present changes in industrial technology; newer manufacturing methods providing stronger and cheaper iron chain. Initial proposals to use chain were submitted to the Admiralty by Lieutenant Samual Browne in 1811, [25] but not fully implemented until circa 1817. [26]

Iron cables necessitated a different type of stowage other than the standard cable tiers which primarily took up most of the midship section of the orlop. Unlike hemp cables, which needed air circulation to dry, there was no requirement to remove boards for iron cable. As result the thin boards became fixed. By the 1830s, new ships being built were constructed with a continuous orlop using the conventional planking system laying on top of the beams while existing ships, like the *Victory*, where simply and cheaply modified by fixing the short loose planking down. Such modifications are also reflected on other draughts. [27] Obviously with the introduction of chain cable a new design of riding bitt had to be adopted. These designs were variable, some purpose built for new ships building while other were simply modifications to existing riding bitts fitted to ships in service. Those on the *Victory* were altered to accommodate iron cable in 1824. [28] These however were removed shortly after 1924 when restoring to her 1803/05 configuration.

To conclude, the overall change in orlop construction between circa 1760 and 1835 had far- reaching ramifications: Initially this deck of was of limited length comprising two short fixed platforms and a central section of thin loose boards. New technological innovations, such as iron tanks and cables, entirely altered the function of the Orlop. Within the aforesaid time span, this deck had evolved into that of a continuous planked deck with reduced cable tiers giving greater space for storerooms, sailrooms, and cabins. Finally, the fact that the deck was now planked in the conventional manner hull strength was considerably improved. This corresponded fully with other innovative changes in hull design at the time. New design criteria called for a more rigid hull system by use of diagonal riders and iron fittings. Such modifications, supported from a new breed of constructors such as Tucker, Lang and Edye were officially authorised by Sir Robert Seppings when he was appointed Surveyor of the Navy in 1813. Now, with the fully planked rigid orlop effectively closing off the lower regions of the ship, the path was laid to meet the introduction of steam machinery into the wooden warship. The orlop on the *Victory* however was to remain in its transitional form.

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Fig. 9/1. "Victory": Orlop Deck Construction, pre 1816.

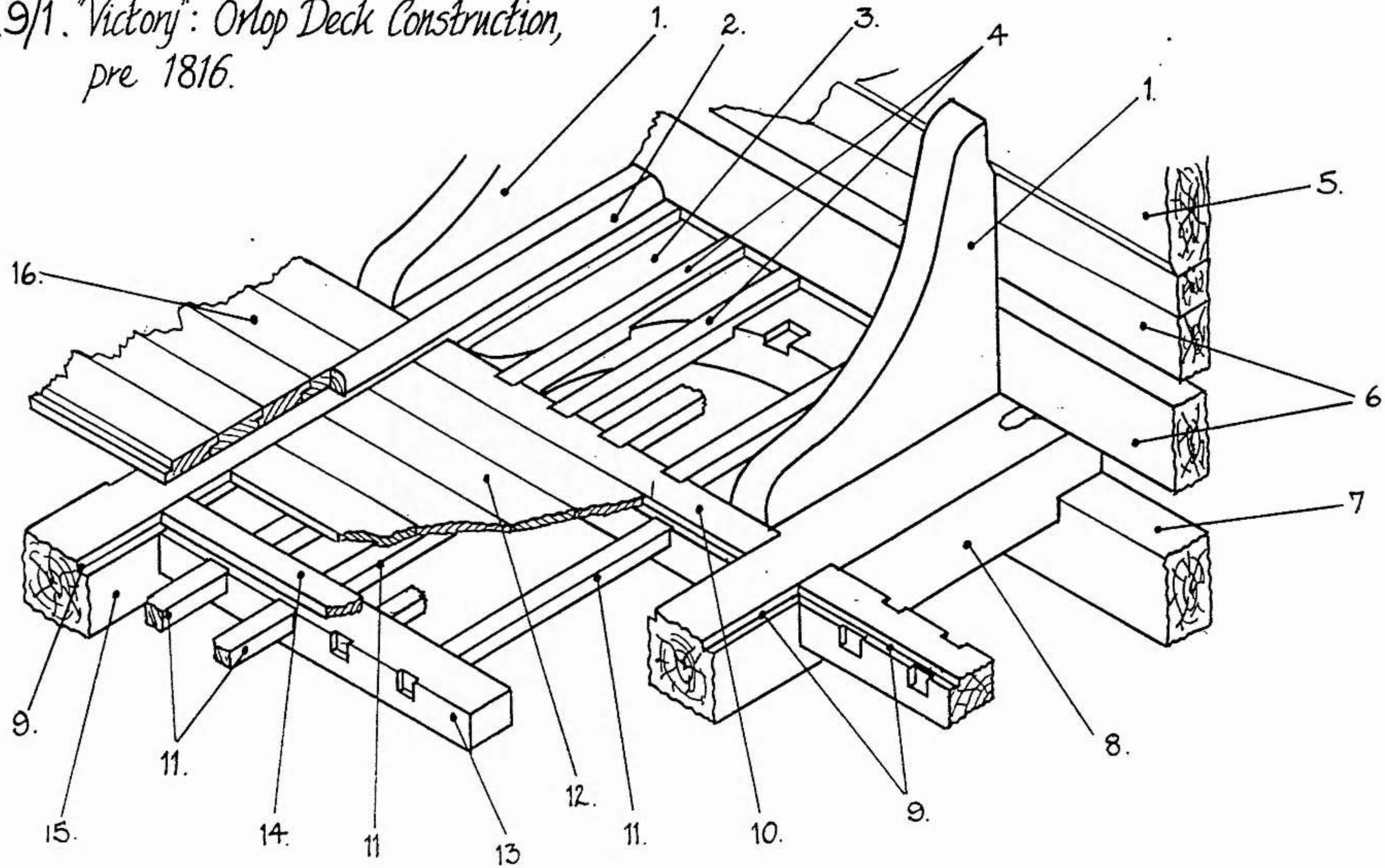


Figure 9/1. *Victory*: Orlop deck construction pre 1816

Key:

1. Orlop Standard
2. Threshold fillet
3. Lodging Knee.
4. Side tier of fixed Ledges - 5 x 4 inches.
5. Lower Gun Deck Clamp (or beam Shelf).
6. Internal ship's side planking.
7. Orlop Deck Clamp (or beam Shelf).
8. Orlop Deck.
9. 1.1/2 x 1.1/2 inch rabbet to receive 1.1/2 inch loose deck boards.
10. Fixed Carling - 10 x 9 inches; rabbeted 1.1/2 inches on inboard edge.
11. Loose fitted Ledges - 5 x 4 inches.
12. Loose fitted Deck Boards - 1.1/2 inches thick.
13. Loose fitted Carling - 10 x 8.1/2 inches.
14. Loose board fitted over Carling - 6.1/2 x 1.1/2 inches.
15. No. 6 Orlop Beam.
16. Fore Platform planking - 10.1/2 x 3 inches with 1.1/2 inch rabbeted edges.

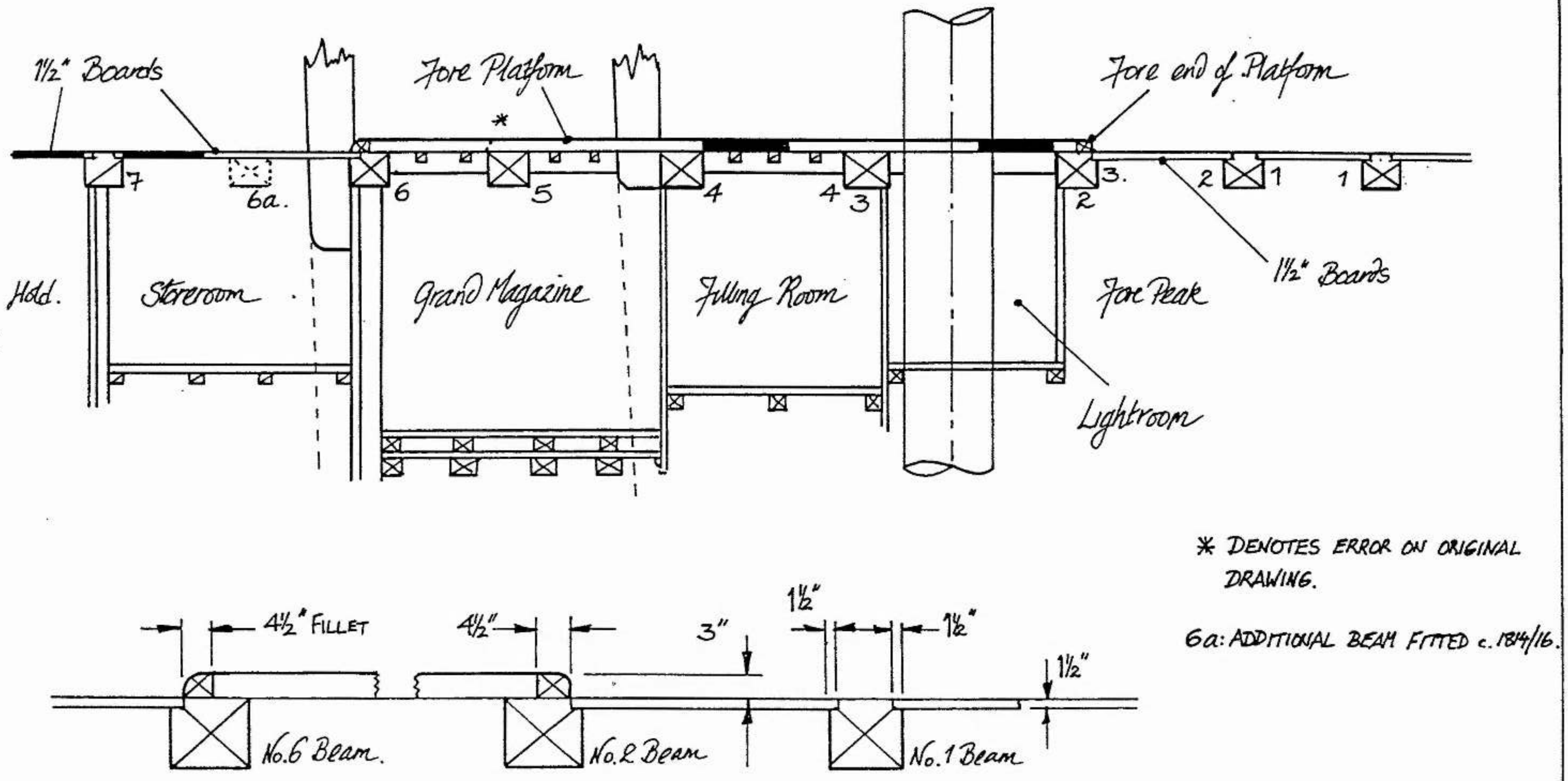


Fig. 9/2. Orlop Form Platform "as fitted" on the 'Victory' before 1814/16.

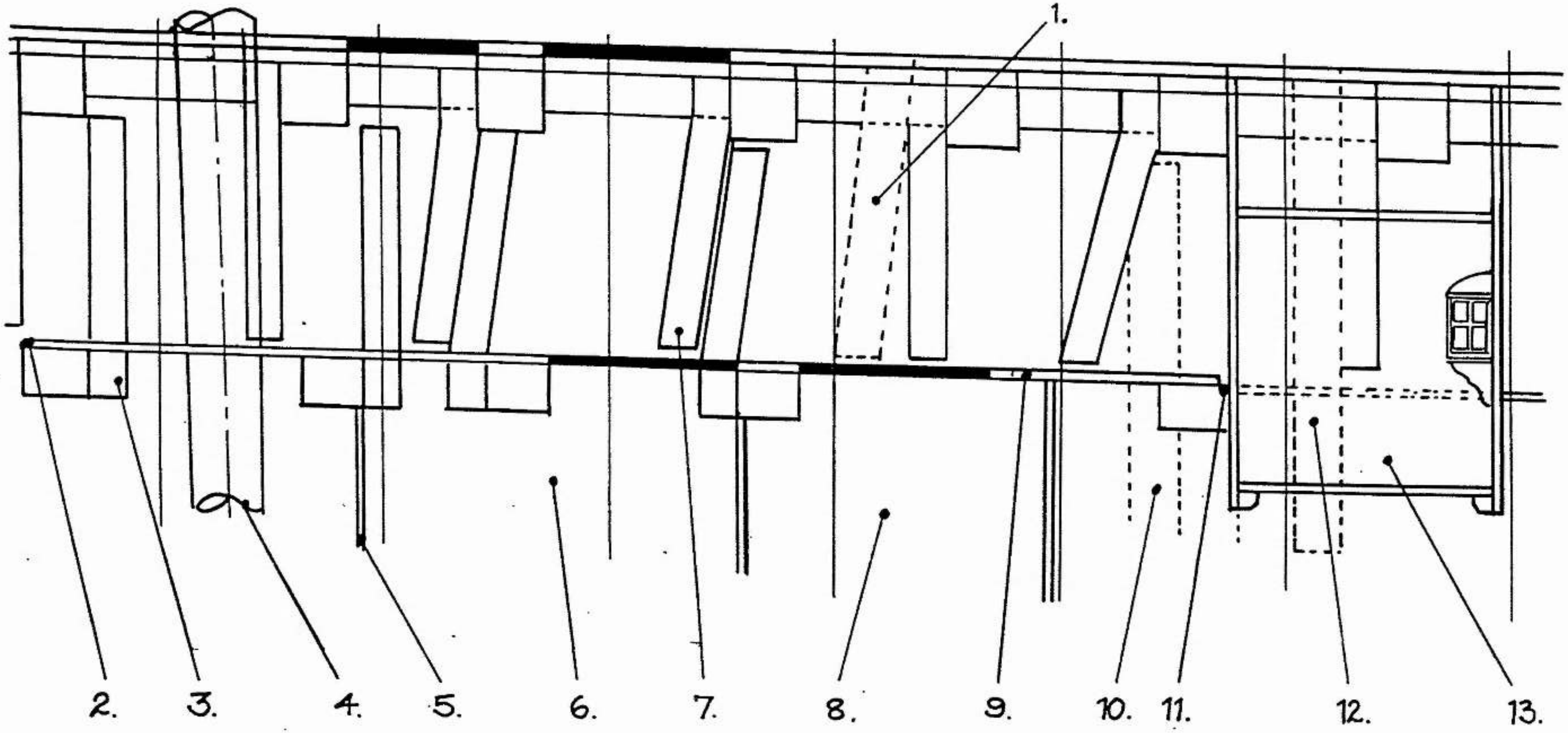


Fig. 9/3. After Platform of the Orlop Deck: H.M.S. Victory; pre 1814/16 construction.

Figure 9/3. After Platform of the Orlop Deck: *Victory*, pre1814/16 construction.

Key:

1. Lower portion of Breadth Rider.
2. Aftermost Orlop Beam (No. 20).
3. Standard (or inverted Hanging Knee).
4. Mizzen Mast.
5. Fore Bulkhead of Bread Room.
6. Spirit Room.
7. Side cast Hanging Knee..
8. Fish Room.
9. After Platform planking - 3 inches thick.
10. After Hold.
11. Foremost end of After Platform.
12. Lower portion of long Breadth Rider.
13. After Hanging Magazine.

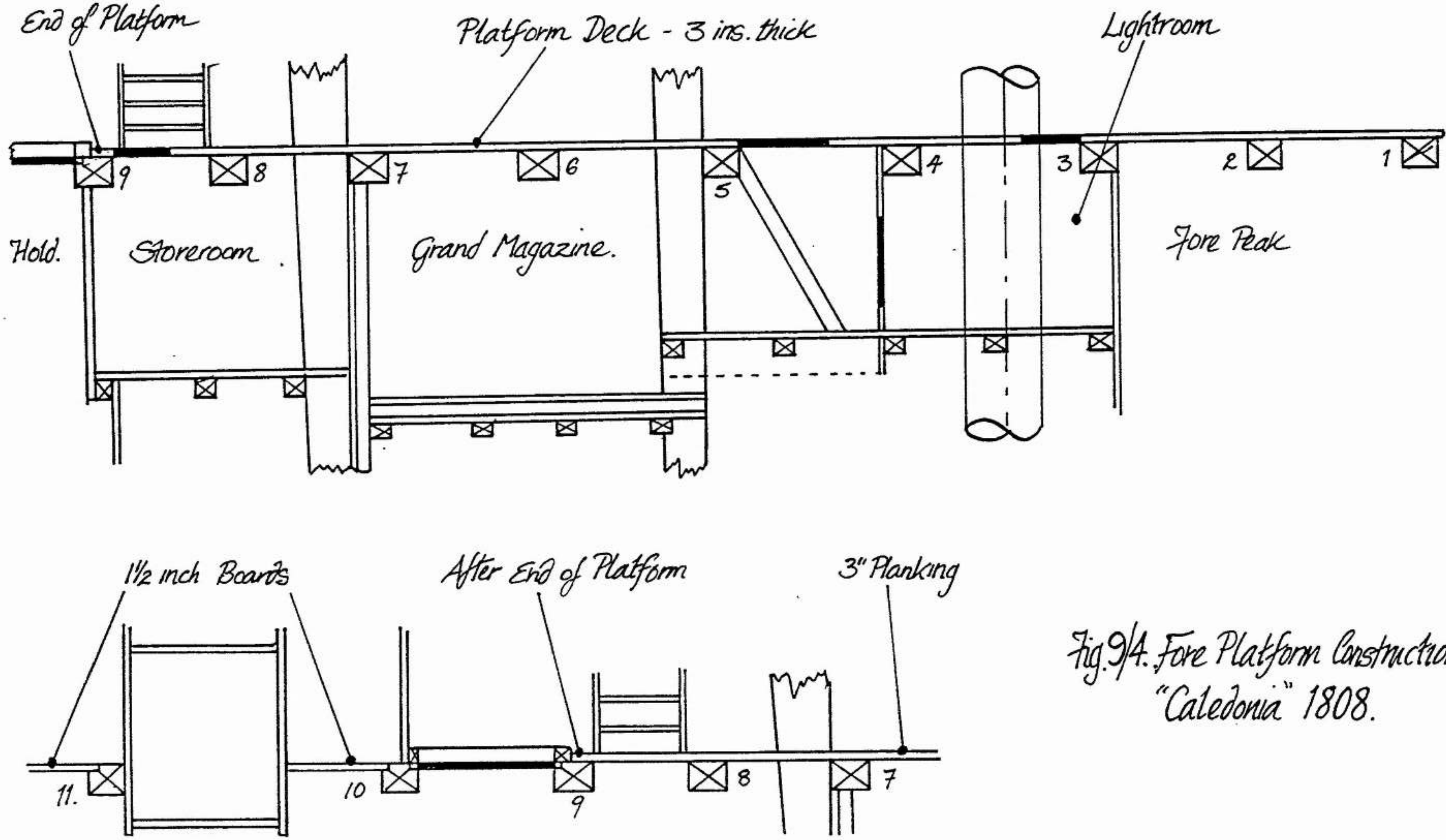
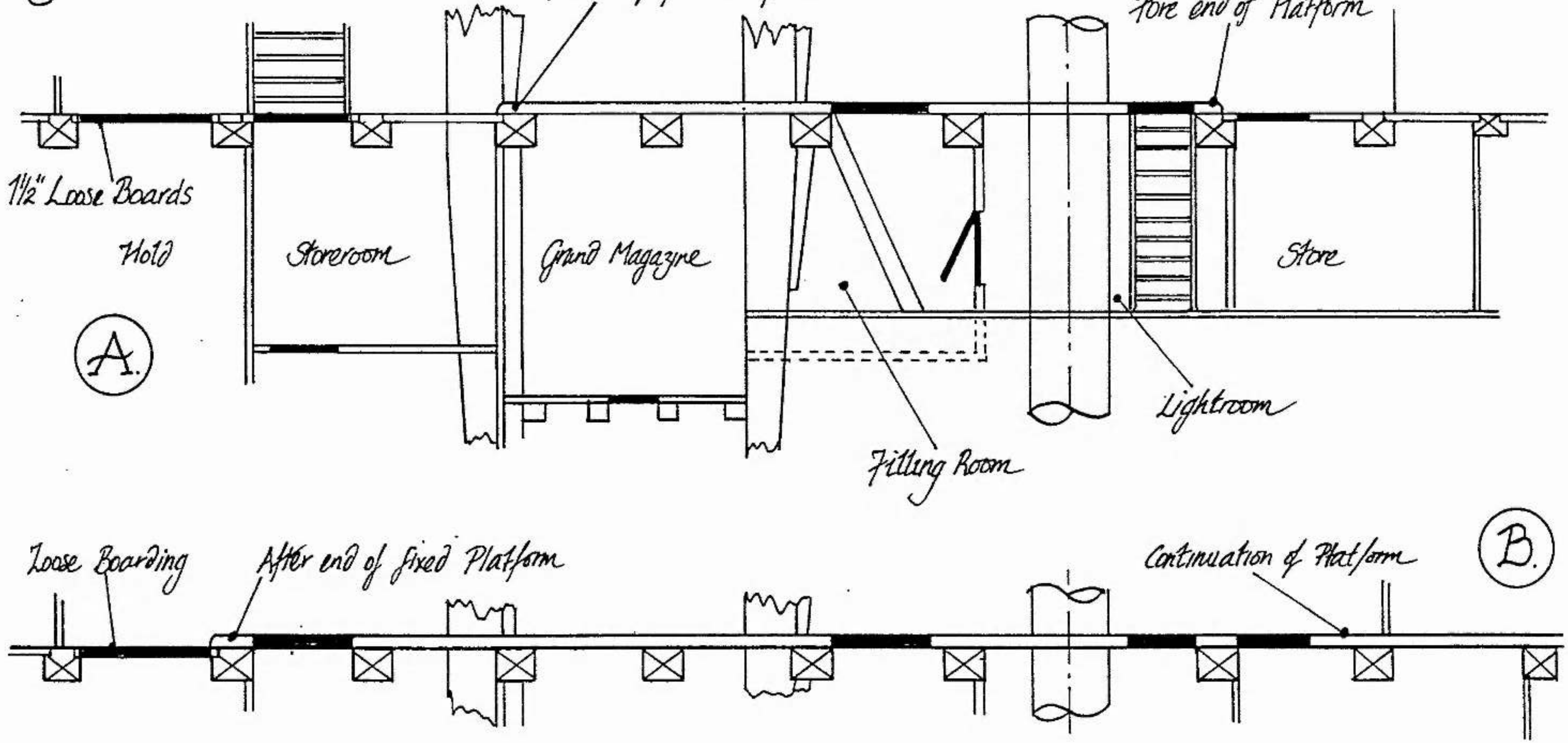


Fig. 9/4. Fore Platform Construction: "Caledonia" 1808.

Fig. 9/5.



Ⓐ 'Hibernia' lines/profile 15th June 1798. Ⓑ 'Hibernia' as modified; lines/profile 1821.

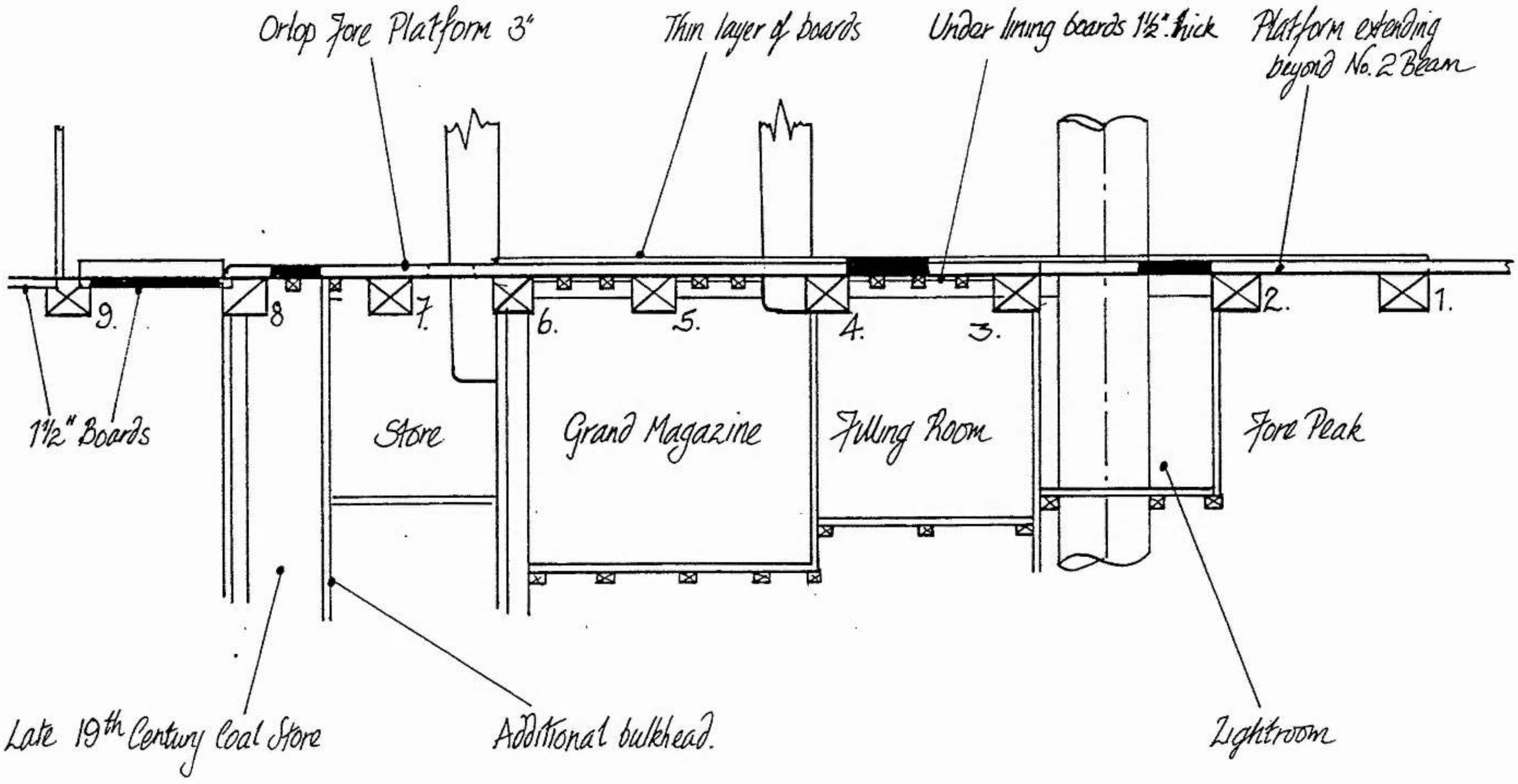


Fig. 9/6. Orlop Fore Platform construction post 1814/16 and later: HMS Victory.

Fig. 9/7. 'Victory'; post 1816 Fore Platform Deck Construction.

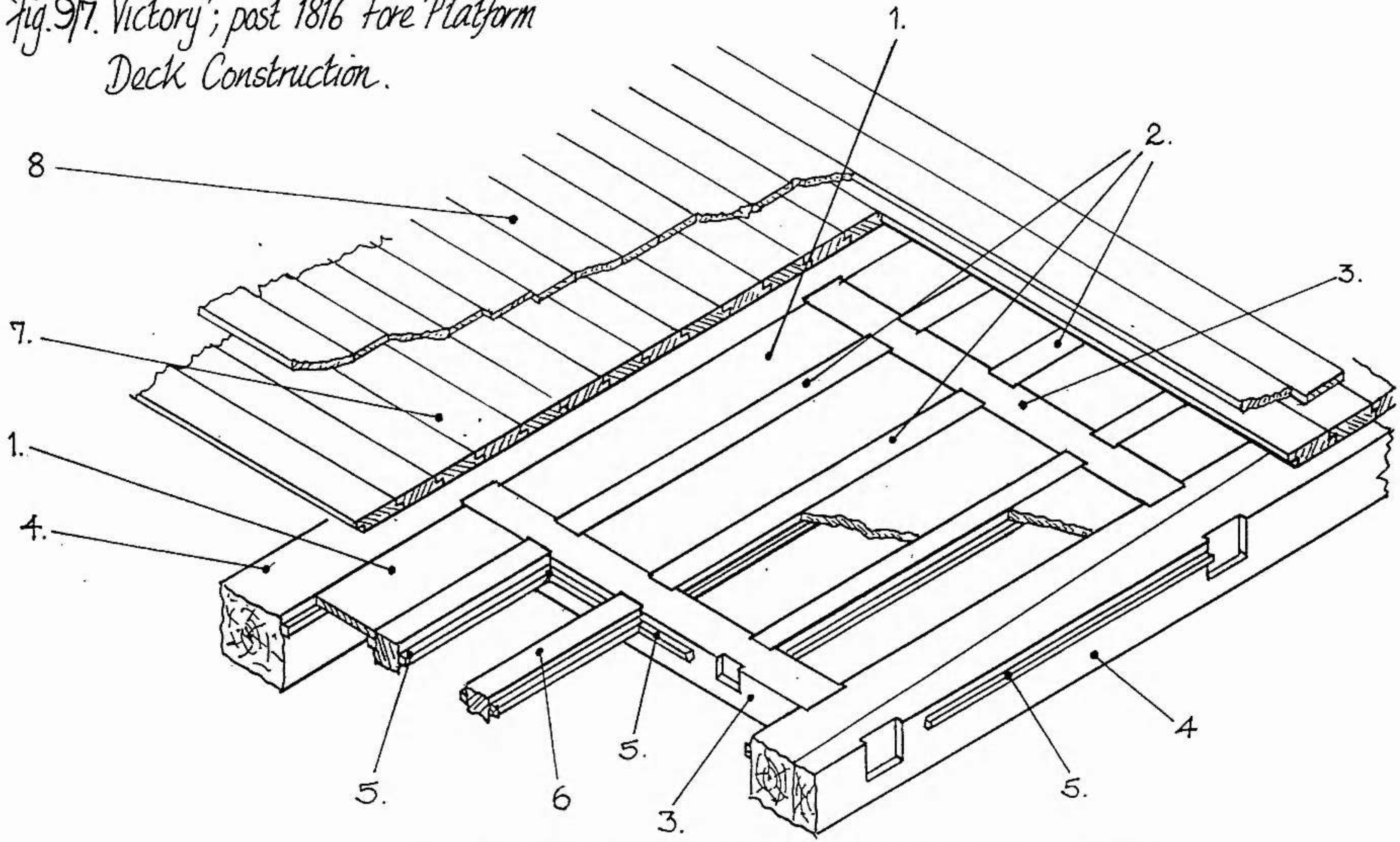


Figure 9/7. *Victory*: Post 1816 Fore Platform deck construction.

Key:

1. Under cladding boards - 1.1/2 inches thick.
2. Ledges - 5 x 4 inches.
3. Carling - 10 x 9 inches.
4. Orlop Beam.
5. Retaining battens - 1 x 3/4 inches.
6. Ledge - 5 x 4 inches.
7. Fore Platform planking - 10.1/2 x 3 inches with 1.1/2 inch rabbeted edges.
8. Deal cladding boards - 9 ins. wide x 1/2 inch thick.

Chapter 10.

Summary of Discussion.

The development of H.M.S. *Victory* throughout her active career epitomises the general progression of war ship design for the period 1759 to 1823. More importantly, and though less obvious, the ship also provides us with a living epitaph portraying the expansion of applied sciences, technology, and the new manufacturing techniques, which collectively relate to what is termed the Industrial Revolution. It was this technological thrust that gave Britain the capacity to maintain her sustained and effective war effort to support the political policies that finally defeated Napoleon in 1815. The aftermath of this struggle was to have even more far reaching effect. Trade and industry flourished on an international scale thereby creating a solid foundation for an expanding British Empire which, albeit short lived by historical standards, exceeded that of any previous nation in the modern world.

The fundamental issues surrounding ship development concern two factors, cause and effect, neither of which are predominant as both are inter-related. In short, the basic criteria that influenced changes in ship design, which though multifarious, are very much integrated, are:

1. Design concept.
2. Tactical requirement.
3. Material procurement
4. The iron and copper industry.

In short, each successive refit or rebuild that the *Victory* underwent reflected new developments of technology be it design or material related:

a. 1759 - 60: Initial build using and innovative design based on French influence.
b. 1780: Application of copper sheathing.
c. 1783: Changeover in hull fastening materials from ferrous to non-ferrous mixed metal' bolts.

d. 1787: Application of breadth, middle, and top riders to strengthen the hull, which in effect, was a preliminary measure that probably formed the basis of the 'trussed frame' system later introduced by Seppings.
Pole masts replaced with made masts using Baltic pine. These were bound with iron hoops.

e. 1800 - 03: Raising of the bulwarks due to the introduction of the carronade.
Closed stern reflecting change in battle tactics and defense.

f. 1810: Possible fitting of first group of iron knees and other ironwork.

g. 1814 - 16: Fitting of iron knees, bracing and brackets.
Reconstruction with the round bow reflecting change in battle tactics, defense together with improved structural design.
Change to orlop construction with the introduction of iron water tanks.

h. 1823: Further changes to the orlop and other fittings with the introduction of iron chain cables.

To expand, design concept not only relates to the issues raised in Chapter 1; i.e. length, breadth, depth and tonnage, &c; and the finer points of hull form influenced by foreign design discussed in Chapter 2; design was also centred around tactical requirements listed above. When the *Victory* was first built the standard method of fighting in fleet actions was to form the squadron in 'line ahead', that is in single file, bow to stern. This arrangement produced an almost impregnable wall of gun-fire directed towards a similarly formed enemy line, ships passing broadside to broadside discharging their ordnance into one another. This method of fighting had been strictly enforced by the Admiralty codes since the Dutch wars of the 17^{th} century. The disadvantage was that it left officers little room to use their initiative or freedom to manoeuvre when wind conditions altered..

At the battle of Cape St. Vincent, 14 February 1797, Nelson himself left the line to prevent the Spanish ships escaping, and by doing so gained an advantage that won the day. Had he failed to achieve his farsighted objectives, his career may have been severely damaged for counteracting the formal Admiralty instructions.

Not only was it sometimes difficult to get ships into formation, but often the advantage of attaining the 'weather gauge' was lost in doing so. In battle it was always the preference to achieve the weather gauge, i.e. to lie to windward of the enemy, in order to take advantage of any wind alterations. This also meant that gun-fire smoke would drift away from the ship towards the enemy thereby hindering the opponents. It also ensured that the gun decks remained free of gun-smoke. The disadvantages of being down wind effectively meant that vessels lying to leeward heeled over exposing the lower part of their hulls to receive shot between 'wind and water'. The other disadvantages were that guns would have to be hauled into the firing position up an inclined deck and that vision was also impaired by the gun smoke that bore down from windward. Moreover, having the weather gauge provided the opportunity to either give chase or break off action when necessary. While this form of fighting remained the accepted practice there was no real necessity to provide greater protection to the head and sterns of men of war; the primary objective being to ensure that the broadsides were built strongly to withstand damage by shot.

A change in tactics brought about through Clerk, and immortalised by Nelson at Trafalgar instigated modifications in design. Not only did new fighting methods attain more decisive results but ships became more exposed to enemy shot from ahead and astern. As a result the closed stern, with additional gun positions was introduced circa 1798, likewise the round bow in 1811. From the constructional view, these innovations produced a far stronger hull less penetrable by shot. Furthermore, lower casualty rates increased morale.

Although the round bow itself did not dramatically increase the complement of ordnance borne, its form very much influenced the introduction of the circular stern proposed by Seppings in 1822. [1] This, with its disposition of gun ports provided an all round defensive arc of fire power. An alternative design, the more aesthetic elliptical stern, supposedly submitted by the sub-surveyor Mr. Roberts in 1819, was introduced some 10 years later. circa 1829. The origins of this design has however been connected with a Mr. Blake. [2]

Gunnery also played its part in the development process. The introduction of the carronade in 1779 necessitated the fitting of built-up bulwarks. Initially these were fitted on a temporary basis during hostilities only to provide better protection for gun crews and the ship from muzzle flash from the new form of gun. Obviously, and very much related to change in tactics, it was found that these modified bulwarks also gave greater protection from enemy small arms fire for those stationed on the upper decks, hence their formal introduction at the turn of the century.

Material procurement greatly altered ship construction techniques. Long periods of war, and the expansion of both the Naval and Mercantile fleets, put considerable pressure on native timber supplies. In addition, the canal building programme, general civil engineering, and the iron industry also contributed to the depletion of vast tracts of forests. This problem was not so acute as some historians have emphasised, however the fact that timber was being consumed on a considerable scale did cause reasonable concern at the time. True, good 'compass' oak for futtocks and knees was scarce therefore more economic methods of construction had to be developed, for example, the beam end chocks introduced by Mr. Roberts. However this form of construction also relied on the use of iron, which is discussed further.

Imported timber was also used for planking and for the manufacture of masts and yards, etc. As expected, imported materials were subject to the ever changing climate of international politics; moreover imports were hampered by constraints implemented by war. From the time that the *Victory* commenced building until 1815, a period of 56 years, Britain was in conflict for 31 years. These wars comprised: The American Revolutionary War - 1775 to 1783: The French Revolutionary War - 1793 to 1802; and the Napoleonic War - 1803 to 1815. In addition one could count the Seven Years War - 1756 to 1763. Ignoring the Seven Years War, which actually expanded the available timber resources, each of the other confrontations brought their own constraints.

The American Revolutionary War temporarily crippled supplies of good timber, especially New England pine which grew to suitable girth and length for making lower masts. Being manufactured from a single tree these masts were termed as 'pole' masts.

To alleviate the situation Britain had to rely heavily on supplies of Baltic pine, which unfortunately did not grow to sufficient size. As a result we turned to manufacturing masts using several trees carefully shaped and scarphed and bolted together, intrinsically forming what was termed a 'made mast'. Coincidentally the French had adopted a similar method of mast construction before Britain. This was probably prompted due to her loss of similar timber supplies from Canada after the Seven Years War. In the long term the 'made mast' proved far stronger than its predecessor. In all probability, the *Victory* received her lower masts of this form during her refit of 1789. It was only during the 1790s that American policy regarding timber altered in Britain's favour but this was short lived as the position deteriorated again when the United States introduced the Embargo Act in 1807 and the Non-Intercourse Act the following year. Britain then had to look to Canada for suitable timber, a course of action further encouraged by the levy of duties on imports from the Baltic. [3]

As stated earlier Britain's alternative supplies of timber, as well as other necessary naval stores; tar, pitch, turpentine and hemp, etc., came from the Baltic. Imports of this nature were crucial for maintaining British warships. The supply of these materials became threatened by various factors. First, in May 1807 the French took Danzig which was a major outlet for exported timber. Second, in July the same year, Napoleon introduced the Treaty of Tilsit permitting him to introduce the continental system and close all Russian and German ports to English shipping thereby hampering essential trade. To compound the problem further, as part of the coalition of the Armed Neutrality, Denmark posed a threat to close the Sound and Great Belt to English merchant ships. This potential hazard was soon eradicated with the seizure of the Danish fleet and bombardment of Copenhagen by the British navy in September 1807. [4] After this date trade slowly improved mainly due to the presence of the Baltic squadron which operated between the spring and autumn each year until 1812. This was led under Admiral Saumarez in the *Victory.* Nonetheless the damage had been done, for faced with the initial shortages of imported timber, iron and copper, Britain had to look inward at its own resources and expand its industry accordingly. With respect to ship construction, scarcity of timber called for more economic use; e.g. chock knees, and greater use was made of native produced wrought iron by Cort's process for the manufacture of brackets and knees, etc. To reiterate from Chapter 7, fittings of this form were fully authorised in 1806, before the second Battle of Copenhagen.

Notwithstanding that Abraham Darby had discovered a better method of smelting iron using clod coal in 1710 the iron industry was still very much reliant on the use of charcoal in 1760. This was an inefficient and costly process. In 1763 Darby II improved the smelting process by introducing the use of coke, coal was not to become commonly used for another decade. Using coke or coal permitted cheaper production thereby making iron a more attractive commodity, thus by 1790 the British iron industry had began to expand rapidly. [5] In 1783 Henry Cort had perfected a cheaper and more efficient method of producing high quality malleable wrought iron. This commodity proved a superb alternative material as a substitute for timber which itself was becoming short in supply. Iron fittings, such as brackets, plate knees, and strapping, became commonly used in shipbuilding especially after 1806. Furthermore its initial use was, together with the innovative guidance of Sir Robert Seppings, Surveyor of the Navy from 1813, to have a far reaching influence in ship design. In addition to the standard iron fittings seen on the *Victory*, later ships were fitted with large diagonally laid iron riders to counteract hogging problems. Examples can be seen on the *Unicorn* frigate at Dundee. In addition to structural fittings, the introduction of iron water tanks replacing wooden casks altered the future construction of the orlop deck. These tanks also eradicated the use of shingle ballast which, though not directly related to construction, did eliminate the potential health hazard to the seamen. Over a long period the shingle began to harbour foul substances from various sources, rotting stores, etc. which gave off obnoxious gases. Not only did better iron production prove suitable to ship construction, it was also to improve armament manufacture. Eventually these factors were to lead Britain into the Steam Age.

Although British industry was prospering well in 1760 it was not yet a revolution as such. [6] To some degree Britain was slow to rise towards an industrial expansion in the wider sense. Though this could mainly be viewed as natural conservatism, it was also initially bereft of support from the government. Any innovation was left primarily with the individual entrepreneurs who could see potential opportunities arising in their own specific fields. France on the other hand was less constrained, her government provided greater patronage towards the development and expansion of her industries related to iron, steel, textiles and coal. This attitude had been firmly established from an earlier part of the 18^{th} century. [7] In all, France gave positive encouragement to the Arts, Manufacture and Commerce. [8] This point is quite evident in comparison to the various points raised regarding their scientific application towards ship design expressed earlier within this thesis. However, once Britain understood the fundamental issues of industrial expansion, the pace developed rapidly and she soon overcame her adversary across the channel. Why France began to lose headway was, in all probability, due entirely to the economic difficulties bought about from the following circumstances;

1. Fall in trade due to the loss of colonies in India and Canada after the Seven Years War.
2. Her costly support of the American cause in 1778.
3. Poor harvests.
4. Revolution in 1789.

These, followed by 22 years of conflict with Britain from 1793 until 1815 momentarily damaged the industrial advance that France had formerly held. For example, as stated previously, the puddling process introduced by Cort did not take effect in France until 1818. It could be argued that the financial burden borne by the British for the Revolutionary and Napoleonic Wars equated with that of France, however unlike France, Britain's national debt was supported by her ability to maintain an economy based on her international trade which was well protected by the Royal Navy.

Turning now to the non-ferrous materials, the copper industry had progressively expanded from the last decade of the 17^{th} century. Initially most of the ore was supplied from the Cornish mines. Prior to this the bulk of copper was imported from Sweden via Holland, and occasionally from Barbary. The supplies from Sweden however fell off in the 17^{th} century due to the disaster that befell the main mine at Falun in 1687 thus copper from Cornwall became a more important source. [9] Further development of the industry was instigated by the introduction of coal as a substitute for wood and charcoal in the smelting process, the latter materials becoming scarce. The discovery of a large ore source at Parys Mountain greatly enhanced the industrial output inasmuch that Britain had, by the 1780s, become the world's major exporter of copper. Much of the credit for this was due to the industrial entrepreneur Thomas Williams who from 1787 monopolised the entire industry. Besides the Cornish mines, at this period he controlled two large mines in Angelsey, smelting works in Lancashire and Swansea, mills at Holywell and in the Thames Valley, and warehouses in London, Birmingham and Liverpool. [10]

It could be conceived that the expansion of the copper industry was related directly with war. Quite the contrary, in truth this material was not part of munitions and other requirements necessary for war, and only became a contributory factor from 1780 when sheathing with copper was needed for naval vessels, and later the mercantile craft. [11]

Britain made considerable advances in metallurgy to produce 'mixed metal' bolts, etc. for ship construction. This alleviated the initial problems of electrolysis between dissimilar metals when sheathing ships with copper. The whole process of the industrial revolution was not primarily to produce cheaper and better products, it was an awakening for people with ingenuity to experiment with new materials 'fit for purpose'. The new alloys produced for general ship building very much resemble the modern alloys used today on naval vessels.

The most common factor that indirectly contributed towards the development, design, and construction of the warship was coal. This fuel alone, which proved a valuable alternative to the dwindling supplies of coppice wood and other timber used for smelting processes, became the major lynch pin of industrial technological progression. Used in a minor capacity for many years, this commodity first made its impact as an industrial fuel in the process of glass manufacture circa 1612. After this date its use remained relatively restricted until circa 1760, when it was first employed in the smelting process of iron. [12]

With the exception of the new methods of manufacturing masts, there remained little change in the approach towards the sailing attributes of ships and its development, the standard ship rig having already reached it zenith. True, the production of sailcloth, ropes and other subsidiary processes had by this period become mechanised with the advance of industrial machinery. The greatest impact in this field lay with the introduction of Brunel's block making machinery which was installed at Portsmouth Dockyard in 1803. Built by Maudsley, this machinery effectively became the first mass production apparatus in the world.

To conclude, thorough analysis of the hull fabric of the *Victory* can provide us with an account of the advances made in industry between 1760 and 1830. First and foremost was copper sheathing, which through cheaper production, permitted our ships to be maintained at a higher state of seaworthiness and thus spent less time in refit. The effects were multifarious;

a. Refit costs were marginally reduced.
b. Greater deployment of warships to confound the enemy throughout the various theatres of war.
c. More ships available to maintain the blockade of enemy ports.
d. More ships available to carry out escort duties to protect commerce.

As a by-product to copper, various innovative non-ferrous alloys were introduced to eliminate the problems of electrolysis caused between copper and iron fittings. The origins of these 'mixed metal' materials were effectively the forerunner of the necessary compound metals used in connection with early steam plant machinery and sea-water associated systems employed today.

Improved iron manufacture, as we have seen, directly or indirectly influenced various aspects of ship design. To recap, these were;

a. Iron braces, bracketing and knees;

   i. Eliminated procurement problems of timber.

   i. Implemented a greater strength to weight ratio for the hull.

   ii. Reduced hogging and sagging problems.

   iii. Paved the way for Seppings' Trussed Frame system of construction.

b. Ordnance;

   ii. Stronger guns of the Blomefield design gave greater confidence to the actual gunners as rate of fire could be increased without fear of the guns exploding.

   iii. In consequence to the success of the carronade, ships construction was altered by introducing protective built-up bulwarks.

   iv. Orlop Deck construction was modified and strengthened by introducing iron water tanks.

What an archaeological analysis of the *Victory* has also shown us is that the Admiralty and the Navy Board were far more foresighted and aware of the contemporary advances made in industry and material manufacture than we may originally have thought. More importantly, the Navy as a whole were quick to adopt new technology, a fact that is contrary to the viewpoint of some twentieth century historians. The realistic attitude taken at the time is well reflected in the contemporary publications, documents, and papers written by such men as Tomlinson, [13] Fincham, [14] and Knowles, [15] to name a few.

Besides the alterations in fighting tactics, and improved production of iron, copper and its associated alloys, the advances of industrial technology were to have an even greater influence on ship construction. While the *Victory* underwent her great rebuild in 1814/16, steam machinery, fueled by coal, was already being adopted within small ships as an alternative motive force independent from the constraints of the natural element of wind power. It was this concept that was shortly to eclipse the long era of the sailing man-of-war that the *Victory* represented and give rise to the metal fighting ships: The ironclad *Warrior* of 1860, and the steel hulled *Dreadnought* of 1906.

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APPENDIX I.

SHIPS DESIGNED BY SIR THOMAS SLADE.

Between the years 1749 and 1769, Slade designed a total of 181 ships of war of varying size and purpose. Quite a considerable number his ship took part in the notable actions during the Seven Years War, The War of the American Revolution, and the French Revolutionary and Napoleonic War.

Most notable is the *Victory* 1765, which served some forty seven years active service.

Notes:

1. For historic reasons the table has been rearranged in annual succession.

2. Class Types are indicated in bold type.

3. Class Names for each class type are listed first irrespective of date.

4. With exception to Class type, ships are arranged according to launch date.

5. Those denoted with and asterisk are vessels on which Admiral Lord Nelson served.

Year Designed	*Class/Ship Name*	*Rate*	*No. Guns*	*Launch Date*
1749	**Hazard**	**Sloop**	**8**	**3.10.1749**
1753	Lowestoffe	5th	32	17.05.1756
1753	Tartar	5th	32	3.04.1756
1753	Argo	5th	32	24.04.1758
1753	**Guadaloupe**	**5th**	**32**	**5.12.1763**
1755	Sandwich	2nd	90	15.05.1759
1755	**Blenheim**	**2nd**	**90**	**5.01.1761**
1755	Dublin	3rd	74	6.05.1757
1755	Norfolk	3rd	74	28.12.1757
1755	Lennox	3rd	74	25.02.1758
1755	Warspight	3rd	74	8.04.1758
1755	Shrewsbury	3rd	74	23.05.1758
1755	Resolution	3rd	74	14.12.1758
1755	**Mars**	**3rd**	**74**	**15.03.1759**
1755	**Hunter**	**Pink**	**10**	**4.02.1756**
1755	Bonetta	Snow	10	4.02.1756
1755	Spy	Snow	10	3.02.1756
1755	**Merlin**	**Snow**	**10**	**20.03.1756**
1756	**Hero**	**3rd**	**74**	**28.03.1759**
1756	Hercules	3rd	74	25.02.1759
1756	**Thunderer**	**3rd**	**74**	**19.03.1760**
1756	Edgar	3rd	64	16.11.1758
1756	Panther	3rd	64	22.06.1758
1756	**Firm**	**3rd**	**64**	**15.01.1759**
1756	Venus	5th	36	11.03.1758
1756	Pallas	5th	36	30.08.1757
1756	**Brilliant**	**5th**	**36**	**27.10.1759**
1756	Southampton	5th	32	5.05.1757
1756	Vestal	5th	32	17.06.1756
1756	**Diana**	**5th**	**32**	**30.08.1757**
1756	Coventry	5th	30	30.05.1757
1756	Lizard	5th	30	7.04.1757
1756	Actaeon	5th	30	30.05.1757
1756	Hussar	5th	30	23.07.1757
1756	Shannon	5th	30	17.08.1757
1756	Trent	5th	30	31.10.1757
1756	Boreas	5th	30	27.07.1757
1756	Liverpool	5th	30	10.02.1758
1756	Maidstone	5th	30	9.05.1758
1756	Active	5th	30	11.01.1758
1756	Cerebus I	5th	30	5.09.1758
1756	Griffin	5th	30	18.10.1758
1756	Levant	5th	30	6.07.1758
1756	Aquilon	5th	30	24.05.1758
1756	Carysfort	5th	30	23.08.1766

1756	Hind	5^{th}	30	22.07.1785
1756	**Laurel**	**5^{th}**	**30**	**Cancelled**
1756	Infernal	Bomb	2 + 8	4.07.1757
1756	Blast	Bomb	2 + 8	27.02.175
1756	Basilisk	Bomb	2 + 8	10.02.17
1756	Carcass*	Bomb	2 + 8	27.01.1759
1756	Mortar	Bomb	2 + 8	14.03.1759
1756	Terror	Bomb	2 + 8	16.01.1759
1756	Thunder	Bomb	2 + 8	15.03.1759
1756	Etna	Bomb	2 + 8	20.06.1759
1756	Vesuvius	Bomb	2 + 8	3.07.1776
1756	Terror (II)	Bomb	2 + 8	2.06.1779
1756	**Thunder (II)**	**Bomb**	**2 + 8**	**18.05.1779**
1756	Carysfort	5^{th}	30	23.08.1766
1756	**Hind**	**5^{th}**	**30**	**22.07.1785**
1757	Bellona	3^{rd}	74	19.02.1760
1757	Dragon	3^{rd}	74	4.03.1760
1757	**Superb**	**3^{rd}**	**74**	**27.10.1760**
1757	Alarm	5^{th}	32	19.09.1758
1757	Eolus	5^{th}	32	29.11.1758
1757	Stag	5^{th}	32	4.09.1758
1757	Minerva	5^{th}	32	17.01.1759
1757	Pearl	5^{th}	32	27.03.1762
1757	Emerald	5^{th}	32	8.06.1762
1757	Glory	5^{th}	32	24.10.1763
1757	**Aurora**	**5^{th}**	**32**	**13.01.1766**
1757	Niger	5^{th}	32	29.09.1759
1757	Quebec	5^{th}	32	14.07.1760
1757	Winchelsea	5^{th}	32	31.05.1764
1757	**Montreal**	**5^{th}**	**32**	**15.09.1767**
1757	Favourite	6^{th}	16	15.12.1757
1757	**Tamar**	**6^{th}**	**16**	**23.01.1758**
1758	**Ocean**	**2^{nd}**	**90**	**21.03.1761**
1758	Arrogant	3^{rd}	74	22.01.1761
1758	Cornwall	3^{rd}	74	19.05.1761
1758	Defence	3^{rd}	74	31.03.1761
1758	Kent	3^{rd}	74	26.03.1762
1758	Edgar	3^{rd}	74	30.06.1779
1758	Goliath	3^{rd}	74	19.10.1781
1758	Audacious	3^{rd}	74	23.07.1785
1758	Zealous	3^{rd}	74	25.06.1785
1758	Elephant*	3^{rd}	74	24.08.1786
1758	Saturn	3^{rd}	74	22.10.1786
1758	Bellerophon	3^{rd}	74	17.10.1786
1758	Vanguard*	3^{rd}	74	6.03.1787
1758	Exellent	3^{rd}	74	27.11.1787

1758	**Illustrious**	**3^{rd}**	**74**	**7.07.1789**
1758	**Asia**	**3^{rd}**	**64**	**15.06.1764**
1758	Essex	3^{rd}	64	28.08.1763
1758	**Africa**	**3^{rd}**	**64**	**1.08.1764**
1758	**Phoenix**	**4^{th}**	**44**	**25.06.1759**
1759	**Victory***	**1^{st}**	**100**	**7.05. 1765**
1759	London	2^{nd}	90	24.05.1766
1759	Impregnable	2^{nd}	90	15.04.1786
1759	Prince	2^{nd}	90	4.07.1788
1759	**Windsor Castle**	**2^{nd}**	**90**	**21.05.1790**
1759	**Romney**	**4^{th}**	**50**	**8.07.1762**
1760	Ramillies	3^{rd}	74	21.07.1765
1760	Terrible	3^{rd}	74	4.09.1762
1760	Monarch	3^{rd}	74	15.04.1763
1760	Russell	3^{rd}	74	12.11.1764
1760	Robust	3^{rd}	74	25.10.1764
1760	Invincible	3^{rd}	74	9.03.1765
1760	Prince of Wales	3^{rd}	74	4.06.1765
1760	Magnificent	3^{rd}	74	20.09.1766
1760	**Marlborough**	**3^{rd}**	**74**	**26.08.1767**
1760	Lowestoffe*	5^{th}	32	5.06.1761
1760	Diamond	5^{th}	32	28.05.1774
1760	**Orpheus**	**5^{th}**	**32**	**7.05.1774**
1760	Mermaid	5^{th}	30	5.06.1761
1760	Hussar	5^{th}	30	26.08.1763
1760	Solebay	5^{th}.	30	9.09.1763
1760	Greyhound	5^{th}	30	20.07.1773
1760	**Boreas***	**5^{th}**	**30**	**23.08.1774**
1761	Barfleur	2^{nd}	90	30.07.1768
1761	Prince George	2^{nd}	90	31.08.1772
1761	Princess Royal	2^{nd}	90	18.10.1773
1761	**Formidable**	**2^{nd}**	**90**	**20.08.1777**
1761	Saint Albans	3^{rd}	64	13.08.1764
1761	Augusta	3^{rd}	64	13.07.1763
1761	**Director**	**3^{rd}**	**64**	**9.03.1784**
1761	Ardent	3^{rd}	64	13.08.1764
1761	Raisonable*	3^{rd}	64	10.12.1768
1761	Belliquex	3^{rd}	64	5.06.1780
1761	Agamemnon*	3^{rd}	64	10.04.1781
1761	Stately	3^{rd}	64	22.12.1784
1761	Indefatigable	3^{rd}	64	July 1784
1761	**Nassau**	**3^{rd}**	**64**	**20.09.1785**
1761	**Nautilus**	**6^{th}**	**16**	**24.05.1762**
1763	**Sherbourne**	**Cutter**	**6**	**3.12.1763**
1763	Ferret	Cutter	6	8.10.1763
1763	**Lurcher**	**Cutter**	**6**	**26.09.1763**

1765	**Egmont**	**3rd**	**74**	**29.08.1768**
1765	Worcester	3rd	64	17.10.1765
1765	Stirling Castle	3rd	64	28.06.1775
1765	**Lyon**	**3rd**	**64**	**3.09.1777**
1766	Elizabeth	3rd	74	17.05.1775
1766	Resolution	3rd	74	12.04.1770
1766	Cumberland	3rd	74	9.03.1774
1766	Berwick	3rd	74	18.04.1775
1766	Bombay Castle	3rd	74	14.06.1782
1766	Powerful	3rd	74	3.04.1783
1766	Defiance	3rd	74	10.12.1783
1766	**Swiftsure**	**3rd**	**74**	**4.04.1787**
1766	Salisbury	4th	50	19.08.1766
1766	**Centurion**	**4th**	**50**	**27.05.1774**
1766	Otter	5th	14	26.10.1767
1766	Swallow	5th	14	30.12.1769
1766	**Falcon**	**5th**	**14**	**15.06.1771**
1769	Culloden	3rd	74	18.05.1775
1769	Thunderer	3rd	74	13.11.1783
1769	Venerable	3rd	74	19.04.1784
1769	Victorious	3rd	74	27.04.1785
1769	Ramillies	3rd	74	12.07.1785
1769	Terrible	3rd	74	28.03.1785
1769	Hannibal	3rd	74	15.04.1786
1769	**Theseus***	**3rd**	**74**	**25.09.1786**
1769	Roebuck	4th	44	28.07.1774
1769	Romulus	4th	44	7.13.1777
1769	Acteon	4th	44	29.01.1778
1769	Janus	4th	44	15.05.1778
1769	Charon	4th	44	8.10.1778
1769	Ulysses	4th	44	14.07.1779
1769	Serapis	4th	44	4.03.1779
1769	Endymion	4th	44	28.08.1779
1769	Assurance	4th	44	20.04.1780
1769	Dolphin	4th	44	10.03.1781
1769	Argo	4th	44	8.06.1781
1769	Mediator	4th	44	30.03.1782
1769	Resistance	4th	44	11.07.1782
1769	Charon (II)	4th	44	17.05.1783
1769	Guardian	4th	44	23.03.1784
1769	Experiment	4th	44	27.11.1784
1769	Regulus	4th	44	10.02.1785
1769	**Gladiator**	**4th**	**44**	**20.01.1785**

APPENDIX II.

COPPER SHEATHING REPLACEMENT & REPAIRS:

HMS VICTORY 1780 - 1888.

1. Sh^{g} (sheathing) taken off and Coppered Mar. 1780. (Sheet No. 3. Folio 4).
2. Copper taken off and Re Copper'd Febr^{y} 1783.
3. Copper taken off Jan 1788. Re Copper'd Nov 1789.
4. Copper taken off and Re Copp'd Jan 1795
5. Copper taken off April 1800. Re Copper'd April 1803.
6. Copper taken off Mar. Re Copper'd April 1806. (No. 4. Folio 10).
7. Copper repaired . (Nov - Dec 1807) .
8. Copper taken off Mar. 1814. recopper'd Jan^{y} 1816.
9. Copper taken off and recopp^{d}. (Jun - Aug 1823)
10. Shifted 6 upper strakes of copper each side. (May - Jun 1827)
11. Copper repaired Jan^{y} 1832
12. (Shifted defective copper on bottom April 1854)
13. Repaired Copper July 1857
14. Repaired 3 strakes of Copper, recoppered the Bottom. Sept 1857 - April 1858
15. Copper stripped (except keel) & bottom caulked, recoppe'd. Dec 1887 - 14 Oct. 1888 (No. 10 Folio 219).

Abbreviations.

Adm.	Admiralty.
Drwg.	Drawing
MM.	Mariner's Mirror
MS.	Manuscript.
MSS.	Manuscripts.
NMM.	National Maritime Museum
NRS.	Navy Records Society
PRO.	Public Records Office
RNM.	Royal Naval Museum

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